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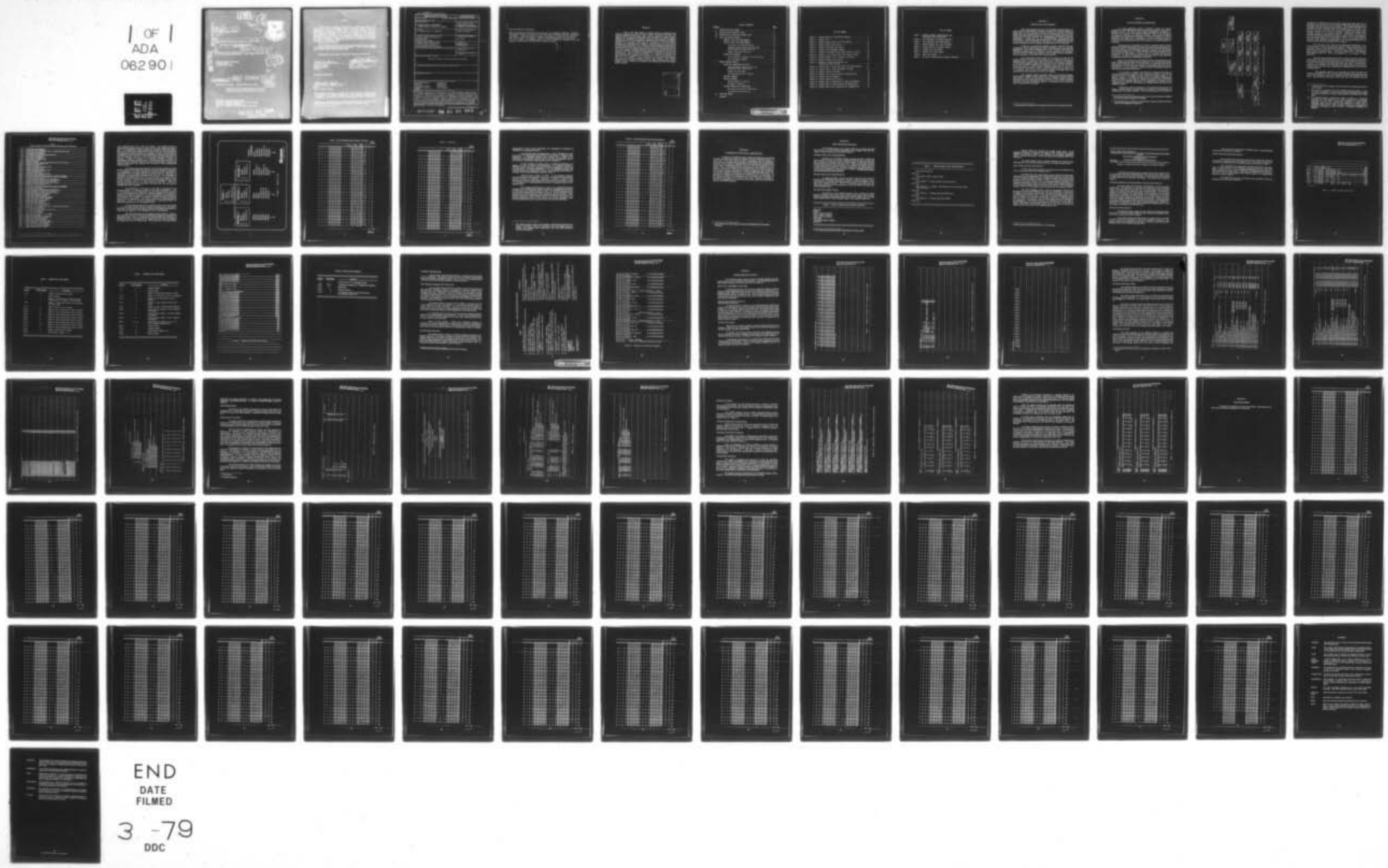

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PART III

KA-BAND RELIABILITY IMPROVEMENT. Part III.

User's Manual for TASA/DEPEND Program.

J. E. Brennan and J. L. Easterday

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Battelle Columbus Laboratories
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This report contains details instructions for using the DEPEND computer program to evaluate dependability, availability, reliability and other performance parameters for avionics and other systems and subsystems on aerospace vehicles. The program is run as the evaluation step in a comprehensive system performance analysis. In this manual, extensive computer experience is not assumed, but the user should have a basic knowledge of computer usage, and a technical understanding of the functional relationships among components of the system to be analyzed, and the effect on system, subsystem, and functional assembly perfor- (Continued)

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mance resulting from malfunctions and failures of the system components. Complete information is given for setting up the input data, obtaining a run and interpreting the results. Figures defining the punch card formats for input data are provided that can be used as data sheets. Examples illustrating the use of the program are also included. The DEPEND program is written in FORTRAN IV language for the CDC Cylber 70, 6000 Series and 7000 Series computer systems.

PREFACE

This is the Final Report on studies related to Ka-Band System Reliability Improvement under Air Force Contract No. F33615-75-C-1208. The report is organized in three parts. Part I, Volume I, depicts the system model as organized in its functional relationship form; describes the overall program; presents the probabilistic estimates of reliability, maintainability, availability, dependability, etc. of the Ka-Band SATCOM Set based on all the data available; identifies the components most likely to malfunction or fail; and presents guidelines for the specification of reliability and maintainability requirements for the next generation system. Part I, Volume II, contains Appendix B which presents detailed results of the Tabular System Analysis (TASA) of the Ka-Band SATCOM Set. Part I, Volume III contains Appendix C which presents detailed results of the numerical reliability, availability and dependability predictions for the Ka-Band SATCOM Set. Part II contains guidelines for an Integrated Reliability and Maintainability (R/M) Program Plan intended as a model for the specific R/M plans that will be required for the procurement of future generation systems. Part III is the DEPEND Computer Program User's Manual. The DEPEND (Determination of Equipment Performance and Expected Nonoperational Delay) program is used to perform the arithmetic and documentation for the Tabular System Analysis.

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SECTION I

INTRODUCTION AND SUMMARY

This manual describes the use of the DEPEND* computer program to obtain values for dependability, availability, reliability and related performance parameters for all the assemblies of a system's functional hierarchy. The model utilized with this program provides for the use of alternative malfunction and failure definitions and calculates the corresponding probabilities of assembly malfunction or failure; that is, the undependabilities, unavailabilities and unreliabilities. The DEPEND program keeps track of all the organizational details of the model as well as performing the arithmetic. The mathematical basis and historical development of this technique are described in Part I of this report.

Except for two subroutines, DEPEND is coded in FORTRAN Extended 4.6 language. The two subroutines are coded in COMPASS which is the assembly language for Control Data Corporation (CDC) Cyber 70 Series, 6000 Series and 7000 Series computer systems. DEPEND is currently operational on the Wright-Patterson AFB CDC 6600 computer system. Some adaptation will be required to operate the program on other than CDC computer systems.

The mathematical models, details of the analysis methods and the results obtained in an analysis of an airborne EHF communications terminal are presented in Part I of this 3-part final project report. Part II is an integrated Reliability/Maintainability Program Plan that uses the TASA/DEPEND methodology as a tool for program visibility and management control. This part, Part III, of the project report is a User's Manual, containing instructions for use of the TASA/DEPEND methodology. Extensive computer experience is not required, but it is assumed that the user has detailed technical knowledge about the organization and functioning of the system to be analyzed.

The complete analysis procedure consists of the three processes, Tabular System Analysis (TASA), acquisition of the required functional element data (MTBF or MTTR) and computation using the DEPEND computer program. Although the primary concern of this part of the report is to provide the detailed instructions for using the DEPEND program, it is necessary to also discuss the other two processes of the analysis.

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* Determination of Equipment Performance and Expected Nonoperational Delay.

SECTION II

TABULAR SYSTEM ANALYSIS (TASA)

It is usual engineering practice to describe a system as a nested organization of interdependent and interacting devices operating to accomplish a specified function. To assess overall system dependability, availability, or reliability, it is necessary to consider the individual "ilities" of the components and subsystems which are the constituent elements. This assessment requires considering the consequences of malfunctions or failures occurring in the various subsystems, both singly and in combination, in terms of functional states of components and other assemblies that can be defined in an overall description of the system.

The initial step in an application of TASA is to develop a chart or charts showing the functional hierarchy of the elements, assemblies and subsystems that make up the system. The partitioning of the system into functional assemblies is not critical with respect to the DEPEND program. However, it is recommended that the partitioning be done in a way that simplifies the determination of the consequences of malfunctions or failures; that is, simplifies the functional complexity. Otherwise, the consequence determination step of TASA (which will be described later) becomes unnecessarily complicated.

Figure 1 is an example of a functional hierarchy that describes the upper levels of the airborne Ka-Band SATCOM Terminal*. The Ka-Band Terminal has three primary functional links, the forward link, the report-back link and the conference link. Part of the system elements are functionally common to two or more links**. It is also necessary to consider the system initialization (start-up) function and the primary power source.

It is important to recognize that function is distributed across time as well as across hardware components. This is illustrated in Figure 1 by noting that the three links of the Ka-Band Terminal operate for different lengths of time during a mission. To simplify the logic as well as facilitate computations, functional blocks have been added to express the transition from one functional cycle of use of a specific assembly to the transmission or reception of one message and ultimately the total numbers of messages transmitted and received during the mission.

Concurrently with the development of the functional hierarchy for the system, mutually exclusive functional states are defined for each assembly and subassembly in the system hierarchy. Thus, the functional state of the system is

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* The numbers in the lower left hand corners of the functional blocks are assigned for use as identifiers throughout the analysis.

** Functionally common means that a malfunction or failure will cause more than one link to be degraded or inoperative.

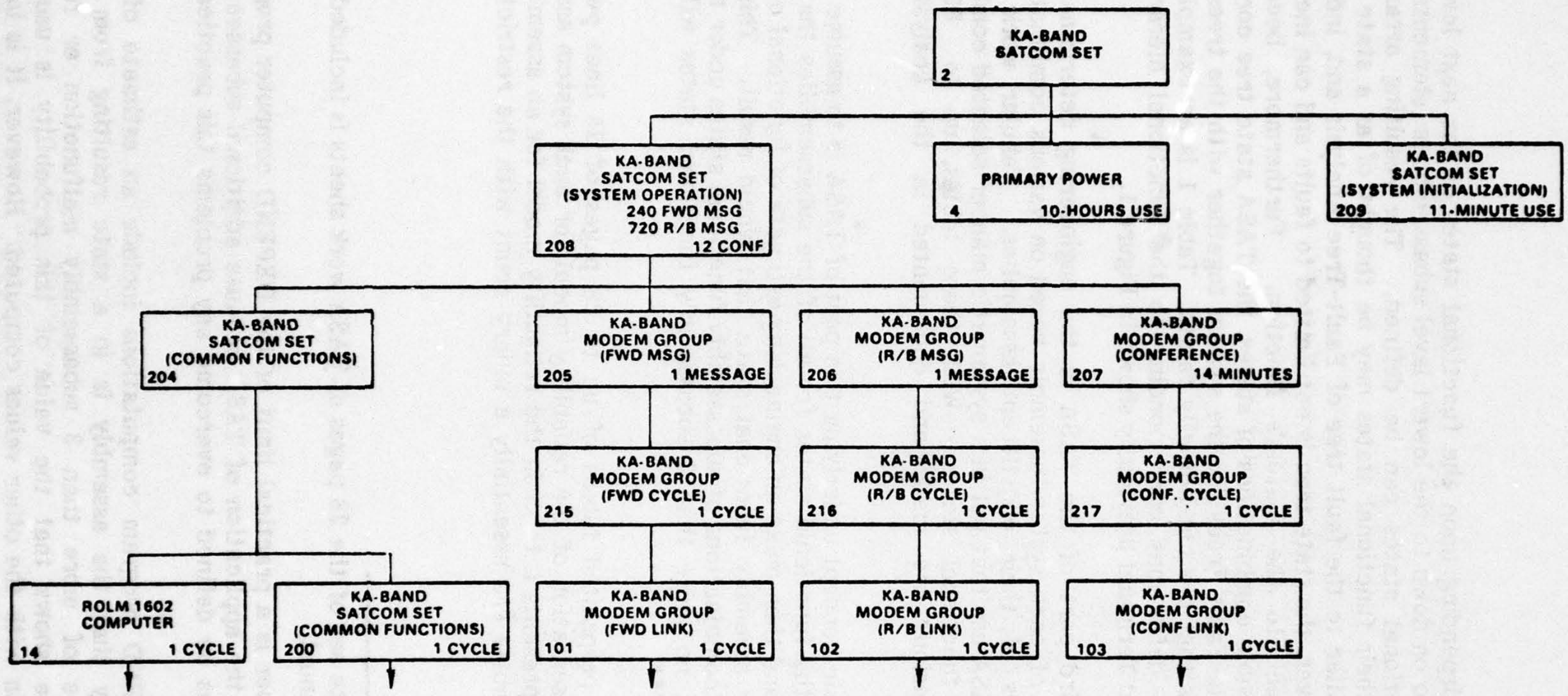


FIGURE 1. KA-Band Satcom Set Functional Diagram

represented as depending upon the functional states of the next lower level of assemblies and so on down to the lowest level subassemblies (elements) for which meaningful functional states can be defined. The resulting arrangement of assemblies and their functional states may be thought of as a state tree. This state tree is similar to the fault tree of Fault-Tree Analysis and, indeed, that is its origin. However, the state tree is not limited to faults and can include almost anything pertinent to the system's function. Furthermore, because TASA considers all possible combinations of states, the TASA state tree corresponds to all of the possible Fault Trees for the system together with the trees associated with other states that are not actually faults. Table 1 is an example listing of functional state definitions corresponding to the functional hierarchy of the airborne Ka-Band Terminal previously shown in Figure 1.

The third part of the TASA is the engineering determination of the functional state of each system assembly based on various combinations of the functional states of their constituent assemblies. Tabular work sheets are provided* for TASA use that list in a systematic manner selected combinations of input assembly functional states. With these tables, up to 697 separate engineering decisions are made and documented in the analysis of each assembly**.

The basic concept underlying this part of TASA is to assume a particular combination of the functional states for all of the subassemblies that make up a given assembly and then make an engineering estimate of functional consequences in terms of the assembly functional state that would result. This process is repeated for all combinations of subassembly functional states under the practical constraints that no more than 3 subassembly functional states will be varied simultaneously.***

The preprinted tables of up to 28 pages of 25 lines per page are a shorthand representation of the reliability model for each system assembly. Each line (or row) represents a term in the reliability model for an assembly functional state. These tables are essentially a binary count with the restriction that only

---

* A complete set of the 28 pages of TASA work sheets is included as Section VI of this manual.

** This number is a practical limit of the DEPEND computer program. It does not limit the application of TASA because additional subassembly groupings can always be defined to overcome any problems this practical limit might cause.

*** The DEPEND program computations include an estimate of a "residual" probability that the assembly is in a state resulting from simultaneous occurrence of more than 3 subassembly malfunction or failure states. Experience shows that the value of this probability is usually small in comparison with the other values computed. However, it is incorporated in subsequent calculations so that its effect is considered throughout the analysis.

TABLE 1

EXAMPLE ASSEMBLY IDENTIFICATIONS AND FUNCTIONAL STATE DEFINITIONS

2.0	KA-BAND SATCOM SET (SUMMARY)
2.1	ALL KA-BAND LINKS INOPERATIVE
2.2	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
2.3	ALL KA-BAND LINKS DEGRADED
2.4	TWO KA-BAND LINKS INOPERATIVE
2.5	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
2.6	TWO KA-BAND LINKS DEGRADED
2.7	ONE KA-BAND LINK INOPERATIVE
2.8	ONE KA-BAND LINK DEGRADED
4.0	SATCOM TERMINAL (PRIMARY POWER)
4.1	PRIMARY POWER FAILURE
14.0	ROLM 1602 COMPUTER
14.1	CPU STOP: NO UPLINK, PRINTER AND CRT EXCEPT FWD. LINK OR CINCNET
101.0	KA-BAND MODEM GROUP (FORWARD LINK)
101.1	INOPERATIVE FORWARD LINK
101.2	DEGRADED FORWARD LINK
102.0	KA-BAND MODEM GROUP (REPORT-BACK LINK)
102.1	INOPERATIVE REPORT-BACK LINK
102.2	DEGRADED REPORT-BACK LINK
103.0	KA-BAND MODEM GROUP (CONFERENCE LINK)
103.1	INOPERATIVE CONFERENCE LINK
103.2	DEGRADED CONFERENCE LINK
200.0	KA-BAND SATCOM SET (COMMON FUNCTIONS)
200.1	ALL KA-BAND LINKS INOPERATIVE
200.2	FORWARD AND CONFERENCE LINKS INOPERATIVE AND R/B LINK DEGRADED
200.3	R/B AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED
200.4	ALL KA-BAND LINKS DEGRADED
200.5	KA-BAND FORWARD AND CONFERENCE LINKS INOPERATIVE
200.6	KA-BAND REPORT-BACK AND CONFERENCE LINKS INOPERATIVE
200.7	KA-BAND FORWARD AND CONFERENCE LINKS DEGRADED
200.8	KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED
204.0	KA-BAND SATCOM SET (COMMON FUNCTIONS)
204.1	ALL KA-BAND LINKS INOPERATIVE
204.2	FORWARD AND CONFERENCE LINKS INOPERATIVE AND R/B LINK DEGRADED
204.3	R/B AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED
204.4	ALL KA-BAND LINKS DEGRADED
204.5	KA-BAND FORWARD AND CONFERENCE LINKS INOPERATIVE
204.6	KA-BAND REPORT-BACK AND CONFERENCE LINKS INOPERATIVE
204.7	KA-BAND FORWARD AND CONFERENCE LINKS DEGRADED
204.8	KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED
205.0	KA-BAND MODEM GROUP (FORWARD MESSAGE)
205.1	KA-BAND FORWARD MESSAGE INOPERATIVE
205.2	KA-BAND FORWARD MESSAGE DEGRADED
206.0	KA-BAND MODEM GROUP (REPORT-BACK MESSAGE)
206.1	KA-BAND REPORT-BACK MESSAGE INOPERATIVE
206.2	KA-BAND REPORT-BACK MESSAGE DEGRADED
207.0	KA-BAND MODEM GROUP (CONFERENCE)
207.1	KA-BAND CONFERENCE INOPERATIVE
207.2	KA-BAND CONFERENCE DEGRADED
208.0	KA-BAND SATCOM SET (SYSTEM OPERATION)
208.1	ALL KA-BAND LINKS INOPERATIVE
208.2	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
208.3	ALL KA-BAND LINKS DEGRADED
208.4	TWO KA-BAND LINKS INOPERATIVE
208.5	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
208.6	TWO KA-BAND LINKS DEGRADED
208.7	ONE KA-BAND LINK INOPERATIVE
208.8	ONE KA-BAND LINK DEGRADED
209.0	KA-BAND SATCOM SET (SYSTEM INITIALIZATION)
209.1	UNABLE TO START SYSTEM
209.2	ALTERNATE INITIALIZATION MODE REQUIRED
215.0	KA-BAND MODEM GROUP (FORWARD CYCLE)
215.1	KA-BAND FORWARD CYCLE INOPERATIVE
215.2	KA-BAND FORWARD CYCLE DEGRADED
216.0	KA-BAND MODEM GROUP (REPORT-BACK CYCLE)
216.1	KA-BAND REPORT-BACK CYCLE INOPERATIVE
216.2	KA-BAND REPORT-BACK CYCLE DEGRADED
217.0	KA-BAND MODEM GROUP (CONFERENCE CYCLE)
217.1	KA-BAND CONFERENCE CYCLE INOPERATIVE
217.2	KA-BAND CONFERENCE CYCLE DEGRADED

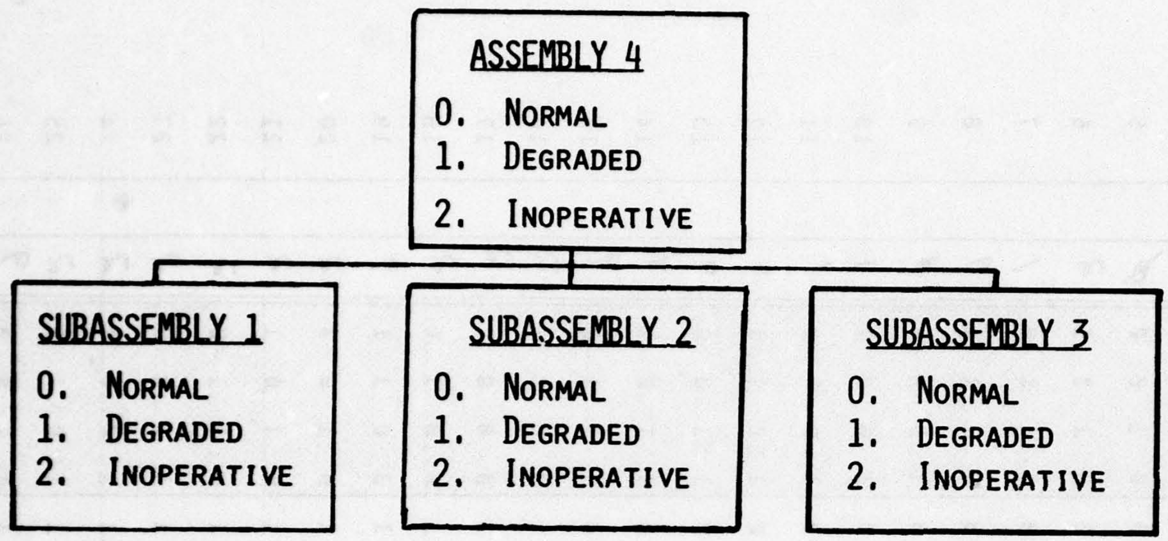
rows containing three "1's" or less are included. The analysis proceeds by assigning input subassembly states to columns of the table working from right to left. A "1" appearing in a column signifies the occurrence of the malfunction or failure state of the input subassembly or element which that column represents. The engineering analysis proceeds by determining for each row of the table the consequences of the combination of input malfunction or failure states denoted by the "1's" appearing in that row in terms of the functional states defined for the assembly. During this analysis it is frequently necessary to assign the consequential assembly functional state for simultaneous input malfunction and failure states on a dominance basis; that is, one input malfunction or failure state produces consequences that dominate over the effect of other simultaneously occurring states.

At the basic level, each column of the TASA table represents an input element malfunction or failure state that has a known probability of occurrence. A "1" appearing in this column signifies the occurrence of that malfunction or failure state while a "0" signifies that the state has not occurred. Thus, there is a "probability of nonoccurrence" associated with each "0". By multiplying the probabilities associated with each of the "1's" and "0's" in a row, one term is obtained of the "ility" equation for the assembly function state assigned to that row by the analyst. The sum of the terms for all rows assigned to a particular assembly functional state is an "ility" model for that state. There is a corresponding model for each malfunction and failure state for each assembly throughout the system hierarchy.

The performance of this part of the TASA is illustrated by the following example. Let Assembly 4 consists of functional subassemblies 1, 2 and 3. The Assembly, and each subassembly, has three mutually exclusive functional states; normal, degraded and inoperative. Whenever Subassembly 1 is inoperative, Assembly 4 will also be inoperative. However, Subassembly 2 and Subassembly 3 are redundant so that Assembly 4 will continue to operate (although in a degraded mode) as long as Subassembly 1 and either of the other two subassemblies are operational. If none of the three subassemblies is operating normally, the assembly is considered to be in the inoperative state.

The functional hierarchy for this example is shown at the top of Figure 2. For this simple example, the list of possible functional states is included in each block. At the bottom of the figure, a number of the possible combinations of states are listed together with the consequence state for the assembly.

The TASA Work Sheet for this example is shown in Table 2. First note that consequence state "9" is reserved for identifying impossible combinations of subassembly states. Since it is required that the functional state definitions be mutually exclusive, it is impossible for one subassembly to be in both the degraded (not failed) state and the failed state. When the TASA work sheet directs



			ASSEMBLY CONSEQUENCE
NORMAL	NORMAL	NORMAL	NORMAL
NORMAL	NORMAL	INOPERATIVE	DEGRADED
NORMAL	NORMAL	DEGRADED	DEGRADED
NORMAL	INOPERATIVE	NORMAL	DEGRADED
NORMAL	INOPERATIVE	INOPERATIVE	INOPERATIVE
NORMAL	INOPERATIVE	DEGRADED	DEGRADED
NORMAL	DEGRADED	NORMAL	DEGRADED

FIGURE 2. EXAMPLE TASA

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TABLE 2. TASA WORKSHEET FOR EXAMPLE ANALYSIS

																		Card Column
										1/12		2/12		3/12				
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0		3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	9		4
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0		5
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2		6
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1		7
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	9		8
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		9
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1		10
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1		11
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	9		12
0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	9		13
0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	9		14
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	9		15
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2		16
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2		17
0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2		18
0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	9		19
0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2		20
0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	2		21
0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	2		22
0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2		23
0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	2		24
0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	2		25
0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	9		26
																		74 - 78
																		00402

TABLE 2. (Continued)

																		Card Column
										1		2		3				
										1	2	1	2	1	2			
																*		1
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1		2
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1		3
0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1		4
0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	9		5
0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1		6
0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	2		7
0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	2		8
0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1		9
0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	2		10
0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	2		11
0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	9		12
0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	9		13
0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	9		14
0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	9		15
0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	9		16
0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	9		17
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0			18
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1			19
0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0			20
0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1			21
0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0			22
0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1			23
0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0			24
0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0			25
0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1			26
																		74 - 78
																		ØØ4Ø3

consideration of such a state combination, the impossibility is indicated by entering "9" as a consequence state*.

The inoperative state of Subassembly 1 is seen to dominate the state of the other two subassemblies (card columns 16-26 of page 1). However, when Subassembly 1 is operating normally, (card columns 1-15 of page 1), the redundancy of Subassemblies 2 and 3 is seen in that only the inoperative state of both results in an inoperative assembly (card column 6 of page 1).

For this example, the analyst chose to consider the assembly to be degraded if there is a fault in any subassembly. In a different example, a different definition might have been used for assembly degradation so that as long as Subassembly 1 and either Subassembly 2 or 3 are operating normally, the assembly operation is considered to be normal. This would affect card columns 2-9 of page 1 of the TASA Work Sheet as shown in Table 3.

Referring back to Page 2 of Table 2, the inoperative assembly consequence shown in card columns 7, 8, 10 and 11 is the result of the requirement that the assembly be considered inoperative if there is a fault in each subassembly. Removal of this requirement would permit card columns 8, 10 and 11 to be changed to "1" indicating that in these cases the assembly would be in the degraded state.

The complete documentation of each of the engineering decisions pertaining to the consequences of a given combination of subassembly malfunction or failure states is an important benefit of TASA. The DEPEND program provides for an optional reproduction of the TASA work sheets. This documentation makes detailed review of the analysis by other engineering personnel practical. This is particularly beneficial where problems have been detected by the analysis. The detailed engineering review of the analysis can provide significant insight concerning possible causes of the problem and potential technical solutions.

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* The DEPEND program checks for "impossible" combinations and corrects the analyst if necessary. When such corrections occur, the analysis should be checked since possible state combinations may have been incorrectly declared as impossible.

TABLE 3. TASA WORKSHEET FOR SECOND EXAMPLE

																		Card Column
										1		2		3				
										1	2	1	2	1	2			
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Ø		2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	Ø		3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	9		4
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	Ø		5
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2		6
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1		7
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	9		8
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	Ø		9
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1		10
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1		11
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	9		12
0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	9		13
0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	9		14
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	9		15
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2		16
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2		17
0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2		18
0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	9		19
0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2		20
0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	2		21
0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	2		22
0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2		23
0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	2		24
0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	2		25
0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	7		26
																		74 - 78
																		ØØ402

SECTION III

ACQUISITION OF FUNCTIONAL ELEMENT DATA

To operate the DEPEND program, MTBF and MTTR data are required for each malfunction and failure state defined for each functional element* of the system. In the early stages of system development, when the emphasis is placed on "ility" prediction, the procedures of MIL-HDBK-217B and MIL-HDBK-472 can be used to predict the MTBF and MTTR for each element malfunction and failure state. The resulting DEPEND outputs are the "ility" predictions for the system. Where actual experience data are available for the functional elements, these data can be used. In this case the DEPEND outputs are an "ility" assessment of the system. Bayesian combinations of predicted, experience and test data can also be used to generate a practical set of element MTBF and MTTR values. One procedure for making such combinations is described in Part 1 of this report. In any case, the credibility and interpretation of the analysis results will depend on the validity and choice of the element data used. Thus, it is necessary to document and substantiate the source of element MTBF and MTTR values used as input for the DEPEND program.

---

* Note that element refers only to the lowest functional block of the system hierarchy.

SECTION IV

USING THE DEPEND PROGRAM

The DEPEND program runs in batch mode from a punched card deck that consists of a control record, relocatable binary program, and four data records. The card deck structure is shown in Table 4.

GENERAL INPUT DATA REQUIREMENTS

Operation of the DEPEND program requires the user to supply four types of data: (1) output control data, (2) assembly identifications and functional state definitions, (3) element MTBF and MTTR values, (4) functional operation data, structure data and fault consequence data. Specific requirements for input of these data are given in the next section. As a general rule, integer data must be right justified in its card field. Fixed point numbers may be placed anywhere in the data field providing the decimal point is included. <u>Floating point numbers must be right justified in their card field.</u>

SPECIFIC INPUT DATA REQUIREMENTS

As stated previously, the input card deck consists of five records in addition to the relocatable binary program. Initially it will be necessary to obtain the assistance of computer operating personnel to compile the program on the user's CDC computer system*. After the relocatable binary deck has been obtained and verified with a check program, the user can assemble the input card deck as described below.

Job Control and Program Records

The operation of the DEPEND computer code to perform the TASA calculation requires a job control record similar to that shown in Table 5 which utilizes a relocatable binary program deck via the INPUT. program call. The copy utility routines are then used to transfer results to the computer output file.

TABLE 5. TYPICAL DEPEND JOB CONTROL RECORD

```
JOBCARD.
INPUT.
COPY, TAPE 9, OUTPUT.
COPY, TAPE 8, OUTPUT.
COPY, TAPE 1, OUTPUT.
(789.) EOR
  Relocatable Binary Program
(789) EOR
```

* The FORTRAN Extended Compiler (FTN) Version 4 should be used.

TABLE 4. DEPEND PROGRAM INPUT DECK STRUCTURE

[Job Control Record]

(789) EOR

[Relocatable Binary Program Deck]

(789) EOR

[Data Record 1 -- Output Control Card and Title]

(789) EOR

[Data Record 2 -- Assembly Identification and Functional State Identification]

(789) EOR

[Data Record 3 -- Element MTBF and MTTR Data]

(789) EOR

[Data Record 4 -- System Functional Model]

(6789) EOJ

Several options are available by deleting control cards. If the paragraph summaries of results* are not desired, TAPE 1 should not be printed. Deleting the printing of TAPE 9 will eliminate the percentage contribution tables*. Deleting the printing of TAPE 8 will eliminate the analysis tables* from the output.

The binary program deck is inserted following the control record. Following this, the four data records are inserted in the order described below.

Output Control and Title (Data Record 1)

The first data record consists of an output control card followed by up to five title cards and ends with a (789) EOR card.

The first card of this record (output control card) contains four logical values and the ATTR Weighting Factor all separated by commas. A .TRUE. value of the first logical variable will cause a listing of the state identifications to be printed. If the second logical variable is .TRUE., a listing of the element MTBF and MTTR values and a listing of the corresponding reliability/unreliability and availability/unavailability values are printed. Setting the third logical variable to .TRUE. causes the analysis tables to be recorded on TAPE 8. if the fourth logical variable is .TRUE. the percentage contribution tables will be recorded on TAPE 9.

The ATTR Weighting Factor is used by the program whenever the calculations involve states including more than one malfunction. In such cases, the largest of the pertinent restore times is extended by a portion of the sum of the other pertinent restore times. If the value of the Weighting Factor is zero, only the longest of the pertinent restore times is utilized. A Weighting Factor value of 1.0 will cause the sum of the pertinent restore times to be employed in the calculations. Intermediate values of the Weighting Factor will cause a corresponding portion of the summed restore times to be used. The first card of Figure 3 illustrates the control card format for the case where all outputs are required and the value of the ATTR Weighting Factor if 0.8.

---

* These outputs are described in Section V of this manual.

.TRUE.,.TRUE.,.TRUE.,.TRUE.,0.8
DEPENDABILITY/RELIABILITY/AVAILABILITY/MAINTAINABILITY ANALYSIS
OF THE
ADM SATCOM COMMUNICATIONS TERMINAL
PREPARED FOR
THE AIR FORCE AVIONICS LABORATORY
(789) EOR

FIGURE 3. EXAMPLE OUTPUT CONTROL AND TITLE RECORD

Following the control card, up to 5 cards may be used to provide a title for the analysis. Each card is an 80-character line of the title that will be printed starting in column 22 of the output title page. If fewer than five cards are used, the (789) EOR card will control the title length. An example title is shown in Figure 3.

Assembly Identification and Functional State Definition (Data Record 2)

The second data record consists of identifications of all the elements, subassemblies and assemblys in the system and definitions of their functional states. The cards may be in any order but it is recommended that the numeric sequence be retained within cards for a given functional block. The first three columns of each card are the identification number assigned for the element, subassembly or assembly; the fourth column is a decimal point and the fifth column is the state number in the range from 0 to 8. State number 0 is used to denote the element, subassembly and assembly identifications. Columns 6 through 10 are not utilized by the computer and may be left blank. The alphanumeric identification corresponding to the numeric identification appears in columns 11 through 80. An example of this data record was shown previously in Table 1. This data record is terminated by a (789) EOR card.

Element Data (Data Record 3)

The third data record contains the input data for the analysis elements in the form of MTBF and MTTR values for each malfunction and failure state. The format of these data is listed in Table 6.

If the number of element states (column 5) is greater than 4, the MTBF and MTTR values are continued on a second card starting in column 16. The element number must be repeated on this card in columns 1-3 and 76-78 and the sequence number 02 is punched in columns 79-80.

Data Record 3 is terminated by a (789) EOR card. An example listing of this data record is shown in Figure 4.

System Functional Model (Data Record 4)

Data record 4 must contain an entry for each nonelemental assembly in the system. Each such entry will consist of two or more cards. The first card describes the characteristics of the assembly using the format listed in Table 7.

The model data for the assembly is entered starting with the second card. This data consists of the consequence assignments from the TASA Work Sheets. There may be up to 697 such assignments depending upon the number of input malfunction or failure states. These data are entered with 25 values per card (26 for the first card) using the format shown in Table 8. An example Data Record 4 is shown in Figure 5.

The (6789) EOJ, end-of-job, card follows the model data for the last assembly and terminates Data Record 4.

```
   4 1     136000 1.155E+03  1.0                                                        401
  14 1     1   4.2 5.177E+02  1.0                                                      1401
 101 2     1 4.2 881.924    0.914 2599.41  0.977                                       10101
 102 2     1 4.2 1028.74    0.504 551.015  1.                                          10201
 103 2     1 4.2 1390.09    0.503 593.092  0.986                                       10301
 108 8     1 4.2 539.761    0.5046784870000.903 48347.9   0.516 1871.11  0.50410801
 108               500.023  0.503 12541.3  0.5    1128.01  1.965 10401.7  0.5   10802
 209 2     1660.  59.3306   0.83513219.2   0.5                                         20901
  40 2     1 4.2 832.225    1.75  28150.   2.0                                          4001
  31 1     1 4.2 1647.67    1.                                                          3101
  32 2     1 4.2 1927.42    2.17  13790.1  0.5                                          3201
  33 1     1 4.2 726.08     0.76                                                        3301
  34 3     1 4.2 3028.02    1.     3226.4  0.92   1567.99  0.5                          3401
  35 3     1 4.2 1065.64    3.     362.95  3.42   2555.0   2.0                          3501

(789) EOR
```

Figure 4. Example Element Data Record

TABLE 6. ELEMENT DATA CARD FORMAT

Column	Field Length	Contents
1-3	3	Element identification number
4	1	Must be blank
5	1	Number of malfunction or failure states value must be in range 0 to 8 inclusive
6-10	5	Number of functional cycles of use during the time, TUSE
11-15	5	TUSE = time of use in seconds
16-25	10	MTBF for first malfunction state in hours
26-30	5	MTTR for first malfunction state in hours
31-40	10	MTBF for second malfunction state in hours
41-45	5	MTTR for second malfunction state in hours
46-55	10	MTBF for third malfunction state in hours
56-60	5	MTTR for third malfunction state in hours
61-70	10	MTBF for fourth malfunction state in hours
71-75	5	MTTR for fourth malfunction state in hours
76-78	3	Element identification number
79-80	2	Card sequence number = 01

TABLE 7. ASSEMBLY DATA CARD FORMAT

Column	Field Length	Contents
1-3	3	Assembly Number
4	1	Blank Column
5	1	Number of malfunction/failure states
6-10	5	Number of functional cycles for assembly
11-15	5	Length of one functional cycle in seconds
16-17	2	Number of input malfunction/failure states
18-19	2	Number of input elements/subassemblies
20-22	3	Identification number of first element/subassembly
23-25	3	Identification number of second element/subassembly
26-28	3	Identification number of next element/subassembly
29-67	13 x 3	Identification numbers of up to 13 more elements/subassemblies
68-73	5	Blank columns
74-76	3	Assembly Number
77-78	2	Card Sequence Number = 01
79-80	2	Blank columns

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```
204 8 5928   4.2 9 2 14200                                     20401
0879699959999994999999999999                                   20402
*399999999999999992999999999                                   20403
*999999999999991999999999999                                   20404
*999999999999999999111191991                                   20405
*999199999199999919999991999                                   20406
*9999                                                          20407
205 2  240 21.0 2 1215                                         20501
0219                                                           20502
206 2  720 12.6 2 1216                                         20601
0219                                                           20602
207 2   12898.8 2 1217                                         20701
0219                                                           20702
208 8     13600014 4204225206207                               20801
08798659754999986596325229                                     20802
*7549522421999999665966555                                     20803
*5933232222229665933222292                                     20804
*65325542299999999944494444                                    20605
*449222221111199999999999999                                   20806
*599944449222111194442144421                                   20807
*999999999999999999999999999                                   20808
*332933222293323222222229999                                   20809
*999999999999999999999999999                                   20810
*999999222922222229222222111                                   20811
*119999999999999999999999999                                   20812
*999999999999999999999999922                                   20813
*292222111922221222221999999                                   20814
*999999999999999999999999999                                   20815
*999999999999999999999999999                                   20816
*991119111111911111111111199                                   20817
*999999999999999999999999999                                   20818
*999999999999999999999999999                                   20819
*99999999999999999999                                          20820
002 8     13600011 3   4209208                                 201
0379699959999994999999999999                                   202
*399999999999999992999999999                                   203
*999999999999991999999999999                                   204
*999999999999999999933293992                                   205
*999299993999992999999991999                                   206
*999911191991999199999919999                                   207
*919999991999999999999999999                                   208
*1119199199919999199999199                                     209
*999919999999911111111111111                                   210
*111119                                                        211
```

Figure 5. Example Tasa Model Data Record

TABLE 8. MODEL DATA FORMAT

Column	Field length	Contents
1	1	0 on first card, "*" on subsequent cards
2-26	25 x 1	Consequence assignments - (Integers 0-9, inclusive)
27-73	47	Blank field
74-76	3	Assembly number
77-78	2	Card sequence number -02 for first card up to a maximum value of 29

RUNNING THE PROGRAM

After the input card deck is assembled, it is entered into the computer via the card reader. The program performs an audit of the input data and issues data error diagnostic messages as required. Also, a summary of run performance is entered into the DAYFILE record printed at the end of the run.

Error Diagnostic Messages and Location Aids

The data audit routines check for a number of common data errors and issue diagnostic messages as required. The program will attempt to examine all of the data input even though errors are encountered so that the number of data debugging iterations is minimized. Table 9 is a listing of the diagnostic messages that may be issued together with an interpretation of meaning. In several cases, the program makes checks of it's stored data and issues diagnostics if errors are detected. These diagnostics should not appear and if they do the help of computer operating personnel is needed.

The computer system will issue a FATAL ERROR - ILLEGAL DATA IN FIELD diagnostic and abort the program if it encouters non-numeric data in a numeric field of the input card decks. This error will also be encountered in certain cases when the number of model (consequence) cards does not agree with the number of subassembly/element states designated on the structure card.

It is essential that the format rules for the data cards be followed. Otherwise the results obtained will be incorrect. A Mode 2 error "*ERROR DATA INPUT * DATA OVERFLOW* diagnostic may result when a floating point entry is not right justified in the card field.

When a FATAL ERROR - INDEX KEY UNKNOWN diagnostic is encountered, the usual meaning is that an assembly has referenced a subassembly or element for which no identification or state definition data have been entered. Thus, either the structure card is incorrect or a subassembly or element is missing.

Run Performance Summary

The program prints a number of DAYFILE messages pertaining to the program operation. In particular, messages are printed giving the starting time*, finishing time* and time used* for important subroutines in the program. The number of passes required by the scheduling routines is also reported. In case of a fatal error these data help to indicate the progress through the program code. An example Run Performance Summary is shown in Figure 6.

---

* These times are in terms of elapsed central processor seconds.

TABLE 9. LISTING OF DEPEND ERROR DIAGNOSTIC MESSAGES

Message	Interpretation
DATA ERRORS DETECTED nnnn ANALYSIS ABORTED	Computations are not possible because of data errors
*** INSUFFICIENT DATA FOR ELEMENT NBR nnn WHICH HAS nn FUNCTIONAL STATES	The number of states required by an assembly conflicts with the number given for the element
*** MISSING ID FOR ELEMENT STATE NBR nnn.n	Missing Identification
*** MISSING IDENTIFICATION FOR ASSEMBLY NBR nnn	Missing Identification
*** ASSEMBLY NBR nnn IS AN ELEMENT - ENTRY IGNORED	Duplicate usage of numerical identification
*** EXPECTED SEQUENCE NBR nnn BUT READ nnn - ENTRY IGNORED	Cards missing or out of sequence. Cards will be dumped until start of next sequence.
*** UNEXPECTED EOF WHILE READING DATA FOR ASSEMBLY NBR nnn	Missing model data
*** MAX STATE NBR IS nn FOR SUBASSEMBLY nnn BUT ONLY COUNTED nn IN ASSEMBLY nnn	Conflict between number of states defined for a subassembly and that needed by the assembly which uses it
*** ASSEMBLY nnn HAS nn SUBASSEMBLY STATES BUT nn WERE COUNTED	Either an error in the number of subassembly states on the structure card or in the number of states defined for one of the subassemblies
*** nnn IS NOT AN ELEMENT - TRANSFER ABORTED	Inconsistent use of numerical identifications
*** DUPLICATE ASSEMBLY NUMBER nnn - ENTRY IGNORED	Duplicate usage of numerical identification
*** ASSEMBLY nnn USES SUBASSEMBLY nnn FOR WHICH NO DATA WERE ENTERED	Missing Data
*** SUBASSEMBLY nnn HAS nn STATES BUT nn ARE SPECIFIED FOR ASSEMBLY nnn	Conflict between number of states defined for a subassembly and that needed by the assembly which uses it
*** UNABLE TO SCHEDULE RUN - nnn ASSEMBLIES ARE UNSCHEDULED AFTER nnn TRIES	Missing elements/subassemblies
*** ILLEGAL NOS VALUE (nnnnn) - ENTRY IGNORED	The number of output states (assembly states) must be in the range from 0 to 8.
*** STORAGE ERROR - READ nnn WHEN I EXPECTED nnn	Computer system error
*** STATE IDENTIFICATION NOT RECORDED ***	Missing state definition
*** EXPECTED ID FOR ELEMENT STATE nnn.n BUT READ ID FOR nnn.n	Missing state definition or out of sequence
MISSION TRUNCATED FOR ASSEMBLY nnn SUBASSEMBLY nnn MAXIMUM CYCLES nnn	The number of cycles specified for the subassembly times its use time is greater than the assembly use time. A correction in number of cycles is made.
CORRECT	The consequence of this impossible state combination has been corrected to "9".
IDXEL ERROR FOR ASSY nnn ANALYSIS ABORTED	Computer system error

```
09.21.26.START READID              4.71199999999998
09.21.26.E+000
09.21.37.FINISHED READID           7.19199999999997
09.21.37.E+000
09.21.37.READID TIME               2.47999999999998
09.21.37.E+000
09.21.37.START ELMTS               7.19699999999997
09.21.37.E+000
09.21.39.FINISHED ELMTS            7.43599999999997
09.21.39.E+000
09.21.39.ELMTS TIME  2.39000000000004  E-001
09.21.41.START ADATA               7.72099999999997
09.21.41.E+000
09.21.48.FINISHED ADATA            8.61799999999999
09.21.48.E+000
09.21.48.ADATA TIME                8.96999999999991
09.21.48.E-001
09.21.49.BEGIN SKEDUL              8.63399999999995
09.21.49.E+000
09.21.58.FINISHED TRY 1            8.98299999999994
09.21.58.E+000
09.21.58.TIME FOR TRY 1 =          3.48999999999989
09.21.58.E-001
09.21.58.TRY=         3.50000000000250  E-002
09.22.00.FINISHED SKEDUL           9.15399999999999
09.22.00.E+000
09.22.00.SKEDUL TIME=              5.20000000000038
09.22.00.E-001
09.22.00.BEGIN XSUB  9.15799999999995  E+000
09.22.29.FINISHED XSUB             9.83799999999996
09.22.29.E+000
09.22.29.XSUB TIME IS              6.80000000000006
09.22.29.E-001
09.22.29.BEGIN ANALIZE             9.83999999999997
09.22.29.E+000
09.23.15.FINISHED ANALIZE          3.34299999999997
09.23.15.E+001
09.23.16.ANALIZE TOOK              2.35899999999996
09.23.16.E+001
09.23.16.      END  DEPEND
09.23.16.     28.746 CP SECONDS EXECUTION TIME
```

Figure 6. Example Run Performance Summary

SECTION V

DEPEND PROGRAM OUTPUTS

The DEPEND program outputs a number of listings relating to the audit of input data as well as the results of the calculation. The following descriptions of these outputs are given in the order they occur in a typical run.

INPUT DATA PROCESSING AND AUDIT

As discussed previously, the input data required for using the DEPEND program includes identifications for the elements and assemblies, definitions of the functional states, MTBF and MTTR data for all the elements, and the functional model structure and state consequence data. Several output listings are provided to document the data used in the run and to aid in the audit or correction of the input data when necessary.

Assembly/Element Identification and Functional State Definitions

As noted previously in Section IV, the assembly/element identification is input as the definition for the normal functional state and has the numeric label ending in .0. The DEPEND program output offers an optional alphanumeric listing of these data in ascending order of the numeric label. An example of this listing was shown previously in Table 1. This listing is obtained by setting the first field of the output control card to .TRUE. and is eliminated if this field is .FALSE. In any case, a sorted list is printed of the numeric labels of all the assembly or element identifications and functional state definitions that were read. An example of this output is shown in Figure 7.

Element Data Listings

Several types of outputs relating to the element data are printed by the computer. These are: input card images, numerical list of elements processed, and optional listings of processed element data.

To provide a record of the element data used in the DEPEND run and to aid the correction of errors or changing of input data, a card image listing of the element data record is printed. An example of this output is shown in Figure 8.

A numerically ordered list of the elements for which data have been read is printed by the computer. This list is useful for cross checking the structure of the functional model and as a record of the elements included in the run. An example of such a list is shown in Figure 9.

LIST OF ASSEMBLY STATES FOR WHICH IDS WERE READ

2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	4.0	4.1	6.0	6.1	6.2	7.0	7.1	7.2	8.0	8.1	8.2
12.0	12.1	13.0	13.1	14.0	14.1	20.0	20.1	21.0	21.1	22.0	22.1	31.0	31.1	32.0	32.1	32.2	33.0	33.1	34.0
34.1	34.2	34.3	35.0	35.1	35.2	35.3	38.0	38.1	38.2	38.3	38.4	38.5	38.6	38.7	39.0	39.1	39.2	39.3	39.4
39.5	39.6	39.7	40.0	40.1	40.2	41.0	41.1	42.0	42.1	43.0	43.1	44.0	44.1	45.0	45.1	46.0	46.1	101.0	101.1
101.2	102.0	102.1	102.2	103.0	103.1	103.2	104.0	104.1	104.2	105.0	105.1	106.0	106.1	106.2	107.0	107.1	107.2	108.0	108.1
108.2	108.3	108.4	108.5	108.6	108.7	110.0	111.0	111.1	111.2	111.3	112.0	112.1	112.2	113.0	113.1	113.2	115.0	115.1	115.2
115.3	116.0	116.1	117.0	117.1	118.0	118.1	119.0	119.1	121.0	121.1	122.0	122.1	123.0	123.1	124.0	124.1	141.0	141.1	142.0
142.1	143.0	143.1	144.0	144.1	145.0	145.1	146.0	146.1	147.0	147.1	151.0	151.1	153.0	153.1	154.0	154.1	154.2	154.3	155.0
155.1	155.2	160.0	160.1	160.2	161.0	161.1	162.0	162.1	162.2	163.0	163.1	163.2	164.0	164.1	164.2	165.0	165.1	166.0	166.1
166.2	167.0	167.1	168.0	168.1	169.0	169.1	170.0	170.1	171.0	171.1	172.0	172.1	173.0	173.1	174.0	174.1	175.0	175.1	176.0
176.1	177.0	177.1	178.0	178.1	179.0	179.1	180.0	180.1	181.0	181.1	182.0	182.1	183.0	183.1	184.0	184.1	185.0	185.1	186.0
186.1	187.0	187.1	188.0	188.1	189.0	189.1	190.0	190.1	191.0	191.1	192.0	192.1	193.0	193.1	194.0	194.1	195.0	195.1	196.0
196.1	197.0	197.1	198.0	198.1	199.0	199.1	200.0	200.1	200.2	200.3	200.4	200.5	200.6	200.7	200.8	201.0	201.1	201.2	202.0
202.1	202.2	203.0	203.1	203.2	204.0	204.1	204.2	204.3	204.4	204.5	204.6	204.7	204.8	205.0	205.1	205.2	206.0	206.1	206.2
207.0	207.1	207.2	208.0	208.1	208.2	208.3	208.4	208.5	208.6	208.7	208.8	209.0	209.1	209.2	211.0	211.1	211.2	212.0	212.1
212.2	213.0	213.1	213.2	215.0	215.1	215.2	216.0	216.1	216.2	217.0	217.1	217.2	311.0	311.1	312.0	312.1	321.0	321.1	322.0
322.1	323.0	323.1	323.2	331.0	331.1	332.0	332.1	333.0	333.1	334.0	334.1	341.0	341.1	341.2	342.0	342.1	343.0	343.1	344.0
344.1	351.0	351.1	352.0	352.1	360.0	360.1	360.2	360.3	361.0	361.1	361.2	362.0	362.1	363.0	363.1	364.0	364.1	914.0	914.1
915.0	915.1	916.0	916.1																

Figure 7. Example of Assembly State Identification Listing

```
ELEMENT DATA INPUT
    4 1     136000 1.155E+03   1.0                                                            401
   14 1     1   4.2 5.177E+02   1.0                                                           1401
  101 2     1 4.2 801.924     0.914 2599.41   0.977                                          10101
  102 2     1 4.2 1020.74     0.504 551.015   1.                                             10201
  103 2     1 4.2 1390.09     0.503 593.092   0.986                                          10301
  100 0     1 4.2 539.761     0.504670407090.0.903 40347.9   0.516 1071.11   0.50410001
  100                500.023     0.503 12541.3   0.5     1120.01   1.965 10401.7   0.5   10002
  209 2     1660. 59.3304     0.03513219.2    0.5                                            20901
   40 2     1 4.2 832.225     1.79  20150.    2.0                                             4001
   31 1     1 4.2 1547.67     1.                                                              3101
   32 2     1 4.2 1927.42     2.17  13790.1   0.5                                             3201
   33 1     1 4.2 726.00      0.76                                                            3301
   34 3     1 4.2 8020.02     1.      3226.4    0.92  1567.99  0.5                            3401
   35 3     1 4.2 1065.64     3.      362.95    0.42  2555.0   2.0                            3501
```

Figure 8. Example of the Element Data Card Image Listing

LIST OF ELEMENTS

4	13	14	21	22	41	42	43	44	45	46	115	116	117	118	119	121	122	141	142
163	164	165	166	161	153	154	155	167	168	169	170	171	172	173	174	175	176	177	178
179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198
199	311	312	321	322	323	331	332	333	334	341	342	343	344	351	352	361	362	363	364
914	915	916																	

Figure 9. Example Numeric List of Elements Processed

By setting the second field of the output control card to .TRUE. two listings of processed element data are obtained. Both listings are ordered by increasing numeric label and include the element identifications and functional state definitions. Also included are the data for number of functional cycles and use time per functional cycle. The first listing documents the MTBF and MTTR values. An example of this listing is shown in Figure 10. The second listing shows the calculated values of reliability and availabiltiy based on these data.* An example of this output is shown in Figure 11 .

Functional Model Data Listings

The DEPEND program output includes two types of listings to document the functional model data. These are a listing of input card images and an optional listing that reproduces the TASA work sheet format to show the details of the state combinations and consequence assignments.

The listing of input card images from the model input deck documents the data used for the DEPEND run. It is a primary means of tracking down errors and debugging the model data. An example page of this listing is shown in Figure 12.

The system functional model is actually documented in the TASA work sheets. Setting the third field of the output control card to .TRUE. causes the computer to reproduce the TASA data in tabular form on a file named TAPE 8. Copying TAPE 8 to output provides a printed record of the TASA including the identification of the elements, subassemblies and assemblies and the consequences determined for each combination of element/subassembly states for each assembly. As a general rule, once the model has been debugged and a finalized copy of this listing obtained the listing will not be printed for runs made with updated element data. However, this listing does provide a comprehensive documentation of the model structure and consequence assignments used for the DEPEND run. An example page of this State Assignment Listing is shown in Figure 13. Note that the listing for just this one assembly continues for 4 more pages of the computer output. The total listing for a system of any size is quite large. A title page is provided for the listing so that it is an independent documentation of the model.

ANALYSIS SCHEDULE

The actual operation of the DEPEND program is to perform the computations for each functional assembly separately once all the necessary input data are available. Prior to the start of any computations a scheduling routine is used to determine the order in which the computations will be performed. This routine prints the resultant analysis schedule showing the elements/subassemblies used by each assembly and the next assemblies to use the results obtained. Since the order of the printed results are in the order in which computations are

* The mathematical model used for the calculation is discussed in Part I of the report.

ELEMENT DATA

LABEL	IDENTIFICATION		CYCLES	USE,SEC	MTBF,HRS	MTTR,HRS
4.0	SATCOM TERMINAL (PRIMARY POWER)		136000.000			
4.1	PRIMARY POWER FAILURE				.11550E+04	1.00
14.0	ROLM 1602 COMPUTER		1	4.200		
14.1	CPU STOP, NO UPLINK, PRINTER AND CRT EXCEPT FWD. LINK OK SINCNET				.51770E+03	1.00
31.0	COMMUNICATIONS TERMINAL POWER		1	4.200		
31.1	COMMUNICATIONS TERMINAL POWER FAILURE				.16477E+04	1.00
32.0	HEAT EXCHANGING		1	4.200		
32.1	NO HEAT EXCHANGING				.19274E+04	2.17
32.2	DEGRADED HEAT EXCHANGING				.13790E+05	.50
33.0	FREQUENCY GENERATION		1	4.200		
33.1	NO/INCORRECT FREQUENCY GENERATION				.72600E+03	.76
34.0	KA-BAND RECEPTION		1	4.200		
34.1	AUTO-TRACK RECEIVER FAILURE				.30280E+04	1.00
34.2	NO KA-BAND RECEPTION				.32264E+04	.92
34.3	DEGRADED KA-BAND RECEPTION				.15680E+04	.50
35.0	KA-BAND TRANSMISSION		1	4.200		
35.1	DEGRADED RF POWER OUTPUT (50 WATTS MAX)	KA-BAND TRANSMISSION			.10656E+04	3.00
35.2	INSUFFICIENT RF POWER OUTPUT (LESS THAN 100 MW)	KA-BAND TRANSMISSION			.36295E+03	3.42
35.3	NO/INCORRECT DOPPLER CORRECTION	KA-BAND TRANSMISSION			.25550E+04	2.00
40.0	ANTENNA CONTROL GROUP (KA-BAND)		1	4.200		
40.1	NO KA-BAND TRANSMISSION AND RECEPTION	ANT CONT GRP			.03223E+03	1.75
40.2	DEGRADED KA-BAND TRANSMISSION AND RECEPTION	ANT CONT GRP			.20150E+05	2.00
101.0	KA-BAND MODEM GROUP (FORWARD LINK)		1	4.200		
101.1	INOPERATIVE FORWARD LINK	KA-BAND MODEM			.00192E+03	.91
101.2	DEGRADED FORWARD LINK	KA-BAND MODEM			.25994E+04	.90
102.0	KA-BAND MODEM GROUP (REPORT-BACK LINK)		1	4.200		
102.1	INOPERATIVE REPORT-BACK LINK	KA-BAND MODEM			.10207E+04	.50
102.2	DEGRADED REPORT-BACK LINK	KA-BAND MODEM			.55102E+03	1.00
103.0	KA-BAND MODEM GROUP (CONFERENCE LINK)		1	4.200		
103.1	INOPERATIVE CONFERENCE LINK	KA-BAND MODEM			.13901E+04	.50
103.2	DEGRADED CONFERENCE LINK	KA-BAND MODEM			.59309E+03	.99
108.0	KA-BAND MODEM GROUP (COMMON FUNCTIONS)		1	4.200		
108.1	ALL KA-BAND LINKS INOPERATIVE				.53976E+03	.50
108.2	FORWARD AND CONFERENCE LINKS INOPERATIVE AND R/B LINK DEGRADED				.67049E+03	.90
108.3	R/B AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED				.40340E+05	.52
108.4	ALL KA-BAND LINKS DEGRADED				.10711E+04	.50
108.5	KA-BAND FORWARD AND CONFERENCE LINKS INOPERATIVE				.50002E+03	.50
108.6	KA-BAND REPORT-BACK AND CONFERENCE LINKS INOPERATIVE				.12541E+05	.50
108.7	KA-BAND FORWARD AND CONFERENCE LINKS DEGRADED				.11200E+04	1.97
108.8	KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED				.10402E+05	.50
209.0	KA-BAND SATCOM SET (SYSTEM INITIALIZATION)		1	660.000		
209.1	UNABLE TO START SYSTEM				.59331E+02	.04
209.2	ALTERNATE INITIALIZATION MODE REQUIRED				.13219E+05	.50

Figure 10. Example Element Data Listing

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ELEMENT DATA

LABEL	IDENTIFICATION		CYCLES	USE,SEC	RELIABILITY	AVAILABILITY	MTTR,HRS
4.0	SATCOM TERMINAL (PRIMARY POWER)			136000.000	.991379E+00	.999135E+00	
4.1	PRIMARY POWER FAILURE				.862064E-02	.865426E-03	1.000
14.0	ROLM 1602 COMPUTER		1	4.200	.999998E+00	.998070E+00	
14.1	CPU STOP: NO UPLINK, PRINTER AND CRT EXCEPT FWD. LINK OR CINCNET				.225355E-05	.192976E-02	1.000
31.0	COMMUNICATIONS TERMINAL POWER		1	4.200	.999999E+00	.999393E+00	
31.1	COMMUNICATIONS TERMINAL POWER FAILURE				.708878E-06	.606734E-03	1.000
32.0	HEAT EXCHANGING		1	4.200	.999999E+00	.998839E+00	
32.1	NO HEAT EXCHANGING				.605299E-06	.112522E-02	2.170
32.2	DEGRADED HEAT EXCHANGING				.846018E-07	.362572E-04	.500
33.0	FREQUENCY GENERATION		1	4.200	.999998E+00	.998954E+00	
33.1	NO/INCORRECT FREQUENCY GENERATION				.160680E-05	.104617E-02	.760
34.0	KA-BAND RECEPTION		1	4.200	.999999E+00	.999066E+00	
34.1	AUTO-TRACK RECEIVER FAILURE				.385290E-06	.330194E-03	1.000
34.2	NO KA-BAND RECEPTION				.361600E-06	.285107E-03	.920
34.3	DEGRADED KA-BAND RECEPTION				.744052E-06	.318029E-03	.500
35.0	KA-BAND TRANSMISSION		1	4.200	.999995E+00	.987028E+00	
35.1	DEGRADED RF POWER OUTPUT (50 WATTS MAX)	KA-BAND TRANSMISSION			.109480E-05	.281125E-02	3.000
35.2	INSUFFICIENT RF POWER OUTPUT (LESS THAN 100 MW)	KA-BAND TRANSMISSION			.321440E-05	.937853E-02	3.420
35.3	NO/INCORRECT DOPPLER CORRECTION	KA-BAND TRANSMISSION			.456621E-06	.782473E-03	2.000
40.0	ANTENNA CONTROL GROUP (KA-BAND)		1	4.200	.999999E+00	.997028E+00	
40.1	NO KA-BAND TRANSMISSION AND RECEPTION	ANT CONT GRP			.140186E-05	.210859E-02	1.750
40.2	DEGRADED KA-BAND TRANSMISSION AND RECEPTION	ANT CONT GRP			.614446E-07	.710454E-04	2.000
101.0	KA-BAND MODEM GROUP (FORWARD LINK)		1	4.200	.999998E+00	.998588E+00	
101.1	INOPERATIVE FORWARD LINK	KA-BAND MODEM			.132206E-05	.103583E-02	.914
101.2	DEGRADED FORWARD LINK	KA-BAND MODEM			.448820E-06	.375784E-03	.977
102.0	KA-BAND MODEM GROUP (REPORT-BACK LINK)		1	4.200	.999997E+00	.997697E+00	
102.1	INOPERATIVE REPORT-BACK LINK	KA-BAND MODEM			.113407E-05	.489800E-03	.504
102.2	DEGRADED REPORT-BACK LINK	KA-BAND MODEM			.211730E-05	.181319E-02	1.000
103.0	KA-BAND MODEM GROUP (CONFERENCE LINK)		1	4.200	.999997E+00	.997977E+00	
103.1	INOPERATIVE CONFERENCE LINK	KA-BAND MODEM			.839274E-06	.361782E-03	.503
103.2	DEGRADED CONFERENCE LINK	KA-BAND MODEM			.196709E-05	.166109E-02	.986
108.0	KA-BAND MODEM GROUP (COMMON FUNCTIONS)		1	4.200	.999994E+00	.995953E+00	
108.1	ALL KA-BAND LINKS INOPERATIVE				.216145E-05	.933311E-03	.504
108.2	FORWARD AND CONFERENCE LINKS INOPERATIVE AND R/B LINK DEGRADED				.171951E-11	.133090E-08	.903
108.3	R/B AND CONFERENCE LINKS INOPERATIVE AND FORWARD LINK DEGRADED				.241307E-07	.106726E-04	.516
108.4	ALL KA-BAND LINKS DEGRADED				.623516E-06	.269323E-03	.504
108.5	KA-BAND FORWARD AND CONFERENCE LINKS INOPERATIVE				.233322E-05	.100545E-02	.503
108.6	KA-BAND REPORT-BACK AND CONFERENCE LINKS INOPERATIVE				.930260E-07	.398675E-04	.500
108.7	KA-BAND FORWARD AND CONFERENCE LINKS DEGRADED				.103427E-05	.174049E-02	1.965
108.8	KA-BAND REPORT-BACK AND CONFERENCE LINKS DEGRADED				.112161E-06	.480679E-04	.500
209.0	KA-BAND SATCOM SET (SYSTEM INITIALIZATION)		1	660.000	.996901E+00	.985987E+00	
209.1	UNABLE TO START SYSTEM				.308526E-02	.139751E-01	.835
209.2	ALTERNATE INITIALIZATION MODE REQUIRED				.138606E-04	.378231E-04	.500

Figure 11. Example of Element Reliability and Availability Data Listing

```
030 7    1 4.2 10 5 31 32 33 34 35       3001
0559699972294993119 3999999             3002
*4229499999939999111913911              3003
*1111119111199472949942243              3004
*1139472443111111111191991              3005
*1111111911119911111119999              3006
*9999111919911111111911111              3007
*9111111111111111111111119              3008
200 8    1  4.215 2106 39                20001
0079599949999939999999999               20002
*2999999999999939199999999              20003
*9999999999990492994 9993               20004
*9999299999199999474795494              20005
*9993999929999919999999999              20006
*9999663919959993999919999              20007
*9199999999999999999999999              20008
*5259599299919999299999199              20009
*9999999999999999999999999              20010
*9999944492994999399999299              20011
*9991999999999999999999999              20012
*9999999999999999999999933              20013
*8919939993999919999919999              20014
*9999999999999999999999999              20015
*9999999999999999999999999              20016
*9922292992999199992999991              20017
*9999999999999999999999999              20018
*9999999999999999999999999              20019
*9999999999999999999111919              20020
*9199919999199999199999999              20021
*999999999999999999999999                20022
*9999999999999999999999994              20023
*9999999999999999999999999              20024
211 2    5  4.211 3 14200101             21101
0219021922199990219999999               21102
*1119999999999999221999999              21103
*9999999999999021999999999              21104
*99999999999999991119 9999              21105
*9999999999999999999999999              21106
*9999111999999999999993999              21107
*9999999999999999999999999              21108
*1119111111911199111999111              21109
*9999111999991119999991119              21110
*999999                                  21111
201 2  240 21.0 2 1211                   20101
0219                                     20102
212 2    8  4.211 3 14200102             21201
0219221902199991221999999               21202
*0219999999999999221999999              21203
*9999999999999111999999999              21204
*9999999999999999922199999              21205
*9999999999999999999999999              21206
*9999111999999999993999999              21207
*9999999999999999939999999              21208
*1119111111911199111999111              21209
*9999111999991119999991119              21210
```

Figure 12. Example Page of Functional Model and Image Listing

```
S T A T E   A S S I G N M E N T S

FOR ASSEMBLY NUMBER  2

      KA-BAND SATCOM SET (SUMMARY)

  2.1   ALL KA-BAND LINKS INOPERATIVE
  2.2   COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
  2.3   ALL KA-BAND LINKS DEGRADED
  2.4   TWO KA-BAND LINKS INOPERATIVE
  2.5   ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
  2.6   TWO KA-BAND LINKS DEGRADED
  2.7   ONE KA-BAND LINK INOPERATIVE
  2.8   ONE KA-BAND LINK DEGRADED

SUBASSEMBLY STATE IDENTIFICATION

  LABEL     IDENTIFICATION
  ----------------------------------------------------------------------------
    4.1 ENT PRIMARY POWER FAILURE
  209.1 ENT UNABLE TO START SYSTEM
  209.2 ENT ALTERNATE INITIALIZATION MODE REQUIRED
  208.1 CMP ALL KA-BAND LINKS INOPERATIVE
  208.2 CMP COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
  208.3 CMP ALL KA-BAND LINKS DEGRADED
  208.4 CMP TWO KA-BAND LINKS INOPERATIVE
  208.5 CMP ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
  208.6 CMP TWO KA-BAND LINKS DEGRADED
  208.7 CMP ONE KA-BAND LINK INOPERATIVE
  208.8 CMP ONE KA-BAND LINK DEGRADED

SUBASSEMBLY STATES
```

4.1	209.1	209.2	208.1	208.2	208.3	208.4	208.5	208.6	208.7	208.8	2
0	0	0	0	0	0	0	0	0	0	0	8
0	0	0	0	0	0	0	0	0	0	1	8
0	0	0	0	0	0	0	0	0	1	0	7
0	0	0	0	0	0	0	0	0	1	1	9
0	0	0	0	0	0	0	0	1	0	0	6
0	0	0	0	0	0	0	0	1	0	1	9
0	0	0	0	0	0	0	0	1	1	0	9
0	0	0	0	0	0	0	0	1	1	1	9
0	0	0	0	0	0	0	1	0	0	0	5
0	0	0	0	0	0	0	1	0	0	1	9
0	0	0	0	0	0	0	1	0	1	0	9
0	0	0	0	0	0	0	1	0	1	1	9
0	0	0	0	0	0	0	1	1	0	0	9
0	0	0	0	0	0	0	1	1	0	1	9
0	0	0	0	0	0	0	1	1	1	0	9
0	0	0	0	0	0	1	0	0	0	0	4
0	0	0	0	0	0	1	0	0	0	1	9

Figure 13. Example Page of State Assignment Listing

performed, this analysis Schedule is an index to the results and to the State Assignment Listing described above. An example Analysis Schedule is shown in Figure 14.

ANALYSIS SUMMARY

The results of the DEPEND calculations are output in both tabular and statement form. A title page is provided to document the date and time of the DEPEND run and the title of the analysis. An example title page is shown in Figure 15.

Tabular Summary of Results

The results of the "ility" computations for each functional assembly are printed in an Analysis Summary on one page of the computer output. An example Analysis Summary is shown in Figure 16. At the top of the summary, the assembly is identified together with the other assemblies which use it if any.

Next are listed the subassembly or element state data employed in terms of the probability of state occurrence during use (unreliability) and unavailability. The entry ENT* following the label denotes an element while CMP** denote a subassembly. The number of functional cycles, the time used per cycle and the average restore time are also listed. Note that the unreliabilities and unavailabilities for the assembly functional states are only printed in the Analysis Summary for the next level Assembly where it is used. In the case the assembly is a top level one, a separate listing is printed on the next page to record the "ility" data and the undependabiltiy, unreliability and unavailabiltiy for each non-normal state. An example of such a System Data listing is shown in Figure 17.

Referring again to Figure 16, the second part of the Analysis Summary records the probabilities of occurrence of each functional state defined for the assembly. The probability of normal operation is the dependability while the probabilities of occurrence of the other functional states are the corresponding undependabilities. An extra "residual" state is included to account for the occurrence of states not explicitly defined including those cases of four or more simultaneous state occurrences. Included in this part of the summary are calculated predictions of the average time between occurrences of the non-normal states and the average time to restore normal operation after such an occurrence.

The combined prediction for ATBO expresses the average time between occurrences of any of the non-normal states. The combined ATTR is the average restore time taking into account the probability of occurrence of each non-normal state.

---

* Entered data

** Computed estimate

ANALYSIS SCHEDULE

ITERATION	ELEMENTS/SUBASSEMBLIES				
1	31	32	33	34	35
2	101				
3	215				
4	102				
5	216				
6	103				
7	217				
8	40	38			
9	100	39			
10	14	200	101		
11	211				
12	14	200	102		
13	212				
14	14	200	103		
15	213				
16	14	200			
17	204	205	206	207	
18	4	209	201		
19	4	209	202		
20	4	209	203		
21	4	209	209		

ASSEMBLY	NEXT ASSEMBLIES			
30	39			
215	205			
205	208			
216	206			
206	208			
217	207			
207	208			
39	200			
200	211	212	213	204
211	201			
201	6			
212	202			
202	7			
213	203			
203	0			
204	208			
200	2			
6	0			
7	0			
8	0			
2	0			

ITERATIONS END

Figure 14. Example Analysis Schedule

"D E P E N D"

(D)ETERMINATION OF (E)QUIPMENT (P)ERFORMANCE (E)XPECTATION AND (N)ONOPERATIONAL (D)ELAY

(TASRA VERSION IV - 3/20/78)

PHYSICS, ELECTRONICS, AND NUCLEAR TECHNOLOGY DEPARTMENT

ENGINEERING PHYSICS AND ELECTRONICS SECTION

BATTELLE-COLUMBUS LABORATORIES

06/15/78

09.22.30.

DEPENDABILITY/RELIABILITY/AVAILABILITY/MAINTAINABILITY ANALYSIS
OF THE
ADM SATCOM COMMUNICATIONS TERMINAL
PREPARED FOR
THE AIR FORCE AVIONICS LABORATORY

Figure 15. Example Title Page for Depend Program Results

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A N A L Y S I S   S U M M A R Y

FOR ASSEMBLY NUMBER 2

KA-BAND SATCOM SLT (SUMMARY)

SUBASSEMBLY STATE DATA

LABEL		NO. OF CYCLES	TIME OF USE, SEC	PROB. OF OCCURRENCE	RESTORE TIME, HRS	SUBASSEMBLY UNAVAILABILITY	IDENTIFICATION
4.1	ENT		136000.00	.86206E-02	1.00	.86543F-03	PRIMARY POWER FAILURE
209.1	ENT	1	660.00	.30853F-02	.84	.13975F-01	UNABLE TO START SYSTEM
209.2	ENT	1	660.00	.13869F-06	.50	.37823E-06	ALTERNATE INITIALIZATION MODE REQUIRED
208.1	CMP		136000.00	.46106E-01	1.39	.28366E-01	ALL KA-BAND LINKS INOPERATIVE
208.2	CMP		136000.00	.71724F-02	1.88	.17227E-02	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
208.3	CMP		136000.00	.56168E-02	1.03	.32666E-02	ALL KA-BAND LINKS DEGRADED
208.4	CMP		136000.00	.29699F-01	3.05	.23586E-01	TWO KA-BAND LINKS INOPERATIVE
208.5	CMP		136000.00	.90275E-06	1.98	.64535E-03	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
208.6	CMP		136000.00	.13871E-01	2.07	.10655F-01	TWO KA-BAND LINKS DEGRADED
208.7	CMP		136000.00	.54579E-02	.67	.21091E-01	ONE KA-BAND LINK INOPERATIVE
208.8	CMP		136000.00	.89847E-02	.99	.28756E-01	ONE KA-BAND LINK DEGRADED

A S S E M B L Y   S T A T E S

STATE	PROBABILITY	ATBO, HRS.	ATTR, HRS.	IDENTIFICATION
0	.7840226476			NORMAL OPERATION
1	.849118F-01	1.44913E+02	1.323	ALL KA-BAND LINKS INOPERATIVE
2	.345488E-02	2.97208E+03	1.881	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
3	.654682E-02	1.59084E+03	1.028	ALL KA-BAND LINKS DEGRADED
4	.402468E-01	2.98697E+02	3.047	TWO KA-BAND LINKS INOPERATIVE
5	.877362E-03	1.10124E+04	1.983	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
6	.177573F-01	6.72404E+02	2.065	TWO KA-BAND LINKS DEGRADED
7	.188618F-01	5.45102E+02	.671	ONE KA-BAND LINK INOPERATIVE
8	.271311E-01	3.92079F+02	.992	ONE KA-BAND LINK DEGRADED
9	.161895F-01			OTHER STATES
COMBINED		5.02127E+01	1.510	

ASSEMBLY 2 OPERATES FOR 36000.000 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .9567965236, RELIABILITY IS .8194246407 AND DEPENDABILITY IS .7840226476.
215.98 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING 1000 FUNCTIONAL CYCLES
AND A DELAY OF 85.56 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

Figure 16. Example Analysis Summary

SYSTEM DATA

2 KA-BAND SATCOM SET (SUMMARY)

LABEL	AVAILABILITY	RELIABILITY	DEPENDABILITY	IDENTIFICATION
2.0	.95600E+00	.91942E+00	.78402E+00	NORMAL OPERATION
2.1	.21959E-01	.66680E-01	.84912E-01	ALL KA-BAND LINKS INOPERATIVE
2.2	.29029E-03	.33590E-02	.34549E-02	COMBINATION OF 1 (2) INOPERATIVE AND 2 (1) DEGRADED KA-BAND LINKS
2.3	.66570E-03	.62663E-02	.65460E-02	ALL KA-BAND LINKS DEGRADED
2.4	.10260E-01	.32924E-01	.40247E-01	TWO KA-BAND LINKS INOPERATIVE
2.5	.10879E-04	.90765E-08	.87736E-03	ONE INOPERATIVE AND ONE DEGRADED KA-BAND LINK
2.6	.43552E-02	.14762E-01	.17757E-01	TWO KA-BAND LINKS DEGRADED
2.7	.17541E-02	.10170E-01	.10062E-01	ONE KA-BAND LINK INOPERATIVE
2.8	.35916E-02	.25106E-01	.27131E-01	ONE KA-BAND LINK DEGRADED
2.9	.31722E-03	.12313E-01	.16190E-01	OTHER STATES

Figure 17. Example System Data Listing

Statement of Results

At the bottom of each Analysis Summary is printed a statement summarizing the operation, "ility" results, expected number of occurrences of non-normal states and the delay that the system user is expected to experience in case of a malfunction.

The DEPEND program writes a slightly expanded version of these statements of results on the file named TAPE 1. By copying this file to OUTPUT, a compilation of all the statements of results is obtained. An example page of this listing is shown in Figure 18.

OPTIONAL SENSITIVITY TABULATIONS

When the fourth field of the output control card is set to .TRUE., the DEPEND program will output the results of sensitivity calculations for each assembly onto a file named TAPE 9. Copying this file to OUTPUT produces a printed listing of these results.

Percentage Contribution Tabulations

The results of the sensitivity calculations are presented in terms of the percentage contribution of each element or subassembly state to the unavailability, unreliability and undependability for each defined assembly state. An example page of this output is shown in Figure 19.

From this tabulation the relative importance of each element or subassembly state to the malfunctioning or failure of the assembly can be easily observed. This provides a rational basis for allocating resources to achieve improvement of the assembly. It also gives a basis for specifying "ility" requirements for the elements and subassemblies to assure that the assembly meets it's "ility" goals.

Tracing System Sensitivity

The number of possible paths involved in tracing the percentage contribution to system undependabilities, unreliabilities and unavailabilities makes using a computer routine for this purpose impractical. A large amount of output would be obtained for the large number of low or zero percentage paths which are not of interest. However, a simple calculator procedure has been developed that can be used to evaluate the significant percentage contribution of components to the system undependability, unreliability and unavailability.

The assembly sensitivity tabulations from the DEPEND program results are used in a top-down chain calculation that proceeds as follows.

```
                                   SUMMARY OF RESULTS

ASSEMBLY  36 KA-BAND TERMINAL GROUP
IS USED BY ASSEMBLY(S)   59
OPERATES FOR       4.200 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .9933630675, RELIABILITY IS .9999907385 AND DEPENDABILITY IS .9933599681.
    16.64 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING 1000 FUNCTIONAL CYCLES
AND A DELAY OF     83.84 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 215 KA-BAND MODEM GROUP (FORWARD CYCLE)
IS USED BY ASSEMBLY(S) 205
OPERATES FOR       4.200 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .9985087717, RELIABILITY IS .9999982203 AND DEPENDABILITY IS .9985070825.
     1.41 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING 1000 FUNCTIONAL CYCLES
AND A DELAY OF     27.95 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 205 KA-BAND MODEM GROUP (FORWARD MESSAGE)
IS USED BY ASSEMBLY(S) 208
OPERATES FOR      21.000 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .9985495497, RELIABILITY IS .9999911512 AND DEPENDABILITY IS .9985407134.
      .34 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING A MISSION CONSISTING OF   240 FUNCTIONAL CYCLES
AND A DELAY OF     20.09 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 216 KA-BAND MODEM GROUP (REPORT-BACK CYCLE)
IS USED BY ASSEMBLY(S) 206
OPERATES FOR       4.200 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .9976979016, RELIABILITY IS .9999967406 AND DEPENDABILITY IS .9976946577.
     2.31 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING 1000 FUNCTIONAL CYCLES
AND A DELAY OF     26.86 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 206 KA-BAND MODEM GROUP (REPORT-BACK MESSAGE)
IS USED BY ASSEMBLY(S) 208
OPERATES FOR      12.600 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .9976996757, RELIABILITY IS .9999902645 AND DEPENDABILITY IS .9976899626.
     1.66 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING A MISSION CONSISTING OF   720 FUNCTIONAL CYCLES
AND A DELAY OF     26.93 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 217 KA-BAND MODEM GROUP (CONFERENCE CYCLE)
IS USED BY ASSEMBLY(S) 207
OPERATES FOR       4.200 SECONDS TO COMPLETE ITS FUNCTION.
THE AVAILABILITY IS .9979777265, RELIABILITY IS .9999971936 AND DEPENDABILITY IS .9979749258.
      .43 MALFUNCTIONS ARE EXPECTED TO OCCUR DURING A MISSION CONSISTING OF   216 FUNCTIONAL CYCLES
AND A DELAY OF     27.02 MINUTES IS EXPECTED WHEN A MALFUNCTION OCCURS.

ASSEMBLY 207 KA-BAND MODEM GROUP (CONFERENCE)
IS USED BY ASSEMBLY(S) 208
OPERATES FOR     898.000 SECONDS TO COMPLETE ITS FUNCTION.
```

Figure 18. Example Page of Compilation of Result Statements

PERCENTAGE CONTRIBUTION TO ASSEMBLY 2 UNAVAILABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES 4.1	209.1	209.2	208.1	208.2	208.3	208.4	208.5	208.6	208.7	208.8	TOTAL
2.1	2.0	31.9	.0	16.7	.0	.0	.3	.0	.1	.1	.1	51.2
2.2	.0	.0	.0	.0	.7	.0	.0	.0	.0	.0	.0	.7
2.3	.0	.0	.1	.0	.0	1.5	.0	.0	.0	.0	.0	1.6
2.4	.0	.1	.0	.0	.0	.0	23.7	.0	.0	.0	.0	23.9
2.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2.6	.0	.0	.0	.0	.0	.0	.0	.0	10.1	.0	.0	10.2
2.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.1	.0	4.1
2.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	8.3	8.6
TOTAL	2.0	32.0	.1	16.8	.7	1.5	24.1	.0	10.3	4.1	8.5	

PERCENTAGE CONTRIBUTION TO ASSEMBLY 2 UNRELIABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES 4.1	209.1	209.2	208.1	208.2	208.3	208.4	208.5	208.6	208.7	208.8	TOTAL
2.1	4.6	1.7	.0	31.5	.1	.1	.6	.0	.3	.3	.5	39.6
2.2	.0	.0	.0	.0	1.9	.0	.0	.0	.0	.0	.0	2.0
2.3	.0	.6	.0	.0	.0	3.6	.0	.0	.0	.0	.0	3.7
2.4	.0	.0	.0	.4	.0	.0	18.7	.0	.1	.1	.2	19.6
2.5	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.5
2.6	.0	.0	.0	.1	.0	.0	.1	.0	8.4	.0	.1	8.8
2.7	.0	.0	.0	.2	.0	.0	.1	.0	.0	10.3	.1	10.8
2.8	.0	.0	.0	.3	.0	.0	.2	.0	.1	.1	14.3	15.0
TOTAL	4.8	1.7	.0	32.5	2.1	3.8	19.6	.6	8.9	10.9	15.1	

PERCENTAGE CONTRIBUTION TO ASSEMBLY 2 UNDEPENDABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES 4.1	209.1	209.2	208.1	208.2	208.3	208.4	208.5	208.6	208.7	208.8	TOTAL
2.1	4.2	7.5	.0	20.2	.1	.2	.9	.0	.4	.4	.6	42.5
2.2	.0	.0	.0	.0	1.7	.0	.0	.0	.0	.0	.0	1.7
2.3	.0	.0	.0	.0	.0	3.1	.0	.0	.0	.0	.0	3.3
2.4	.1	.1	.0	.5	.0	.1	18.9	.0	.1	.1	.2	20.1
2.5	.0	.0	.0	.0	.0	.0	.0	.4	.0	.0	.0	.4
2.6	.0	.0	.0	.2	.0	.0	.1	.0	8.4	.1	.1	8.9
2.7	.0	.0	.0	.2	.0	.0	.1	.0	.1	8.9	.1	9.4
2.8	.0	.1	.0	.3	.0	.0	.7	.0	.1	.1	12.8	13.6
TOTAL	4.4	7.8	.0	29.4	1.8	3.4	20.3	.5	9.1	9.7	13.8	

Figure 19. Example Page of Depend Sensitivity Tabulation

Utilizing the Percentage Contribution to Assembly listings at the system level (e.g. Assembly 2), select a system state of interest and an assembly state that is a significant contributor to that system state. The computer listings give the percentage contribution of the selected assembly state to the total system undependability, unavailability and unreliability.

From the computer listings for the assembly select the subassembly state of interest and divide it's percentage contribution (from the body of the tables) by the assembly state percentage contribution (from the right-hand column of the table). Multiplying the value previously determined for the percentage contribution of assembly state to the system "ility" by this ratio gives the percentage contribution of subassembly state to the system "ility".

A similar ratio, determined from the subassembly listings and its' product with the subassembly percentage contribution obtained above, gives the percentage contribution of the sub-assembly state to the system "ility". The calculations may be continued down to any desired level included in the computer analysis.

An example illustrating this procedure is as follows: referring to Figure 19, 42.5% of the system undependability is contributed by state 2.1 and about two thirds of this is the 28.2% contribution of assembly state 208.1. From the listing for assembly 208, shown in Figure 20, it is seen that 33.1% of the assembly contribution is attributed to state 208.1, and subassembly 204.1 is responsible for 29.5% of the assembly 208 contribution. Hence, (29.5/33.1) x 28.2% = 25.1% of the system undependability is contributed by subassembly state 204.1.

This process is continued by referring to the sensitivity tabulations for assembly 204 and so on down through the functional hierarchy. The results obtained by tracing all the significant paths may be tabulated to identify and rank the least dependable (or reliable or available) system elements. These results again provide the basis for guiding "ility" improvement and specification efforts.

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PERCENTAGE CONTRIBUTION TO ASSEMBLY 208 UNAVAILABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES 204.1	204.2	204.3	204.4	204.5	204.6	204.7	204.8	205.1	205.2	206.1	206.2	207.1	207.2	TOTAL
208.1	22.5	.0	.0	.0	.2	.0	.1	.0	.2	.1	.2	.3	.1	.3	24.0
208.2	.0	.1	.9	.0	.1	.0	.0	.0	.0	.0	.0	.2	.0	.0	1.5
208.3	.0	.0	.0	2.6	.0	.0	.1	.0	.0	.0	.0	.1	.0	.0	2.8
208.4	.2	.0	.0	.0	18.8	.2	.0	.0	.2	.1	.1	.1	.1	.2	20.0
208.5	.0	.0	.0	.0	.0	.0	.1	.0	.2	.0	.1	.1	.1	.1	.5
208.6	.1	.0	.0	.0	.0	.0	6.7	1.8	.0	.1	.0	.1	.0	.2	9.0
208.7	.1	.0	.0	.0	.1	.0	.0	.0	7.9	.0	5.7	.1	3.9	.0	17.9
208.8	.2	.0	.0	.0	.1	.0	.0	.0	.1	2.7	.0	11.3	.0	9.9	24.4
TOTAL	23.0	.1	.9	2.7	19.4	.2	7.1	1.9	8.6	2.9	6.1	12.2	4.3	10.7	

PERCENTAGE CONTRIBUTION TO ASSEMBLY 208 UNRELIABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES 204.1	204.2	204.3	204.4	204.5	204.6	204.7	204.8	205.1	205.2	206.1	206.2	207.1	207.2	TOTAL
208.1	39.7	.0	.0	.1	.4	.0	.1	.1	.1	.0	.1	.2	.1	.2	41.2
208.2	.0	.1	1.6	.0	.1	.0	.0	.0	.0	.0	.0	.1	.0	.0	1.9
208.3	.0	.0	.0	4.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	5.0
208.4	.4	.0	.0	.0	25.3	.4	.1	.0	.0	.0	.0	.0	.1	.1	26.5
208.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1
208.6	.1	.0	.0	.0	.1	.0	8.5	3.6	.0	.0	.0	.0	.0	.1	12.4
208.7	.0	.0	.0	.0	.0	.0	.0	.0	1.2	.0	1.9	.0	1.7	.0	4.9
208.8	.1	.0	.0	.0	.0	.0	.0	.0	.0	.4	.0	3.5	.0	3.9	8.0
TOTAL	40.4	.1	1.7	5.0	26.0	.4	8.8	3.7	1.4	.5	2.1	3.9	1.8	4.3	

PERCENTAGE CONTRIBUTION TO ASSEMBLY 208 UNDEPENDABILITY

ASSEMBLY STATE	SUBASSEMBLY AND/OR ELEMENT STATES 204.1	204.2	204.3	204.4	204.5	204.6	204.7	204.8	205.1	205.2	206.1	206.2	207.1	207.2	TOTAL
208.1	29.5	.0	.0	.1	.7	.0	.2	.1	.4	.1	.5	.6	.2	.6	33.1
208.2	.0	.1	1.2	.1	.2	.0	.1	.0	.0	.0	.1	.3	.0	.0	2.1
208.3	.1	.0	.0	3.5	.0	.0	.1	.0	.0	.0	.0	.1	.0	.0	3.9
208.4	.6	.0	.0	.1	20.7	.3	.1	.1	.3	.1	.1	.1	.2	.4	23.1
208.5	.0	.0	.0	.0	.0	.0	.1	.0	.1	.0	.1	.1	.1	.1	.5
208.6	.2	.0	.0	.0	.1	.0	7.1	2.5	.0	.0	.0	.1	.0	.2	10.5
208.7	.2	.0	.0	.0	.1	.0	.0	.0	4.4	.0	3.6	.0	2.7	.0	11.1
208.8	.3	.0	.0	.0	.2	.0	.1	.0	.0	1.5	.0	7.0	.0	6.5	15.8
TOTAL	30.8	.1	1.3	3.8	22.2	.3	7.6	2.8	5.3	1.8	4.3	8.4	3.2	7.0	

Figure 20. Example Sensitivity Tabulation for Assembly 208

SECTION VI

TASA WORK SHEETS

Following is a complete set of TASA Work Sheets. These sheets can be reproduced as needed for analyzing the User's system.

																		Card Column
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1			2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0			3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			4
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0			5
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1			6
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0			7
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1			8
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0			9
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1			10
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0			11
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1			12
0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0			13
0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1			14
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0			15
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0			16
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1			17
0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0			18
0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1			19
0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0			20
0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1			21
0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0			22
0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0			23
0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1			24
0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0			25
0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0			26
																		74 - 78

———02

																			Card Column
																*			1
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0				2
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1				3
0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0				4
0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1				5
0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0				6
0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1				7
0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0				8
0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0				9
0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1				10
0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0				11
0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0				12
0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0				13
0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1				14
0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0				15
0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0				16
0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0				17
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0				18
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1				19
0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0				20
0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1				21
0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0				22
0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1				23
0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0				24
0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0				25
0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1				26

74 - 78

______03

																		Card Column
																*		1
0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0			2
0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0			3
0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0			4
0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1			5
0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0			6
0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0			7
0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0			8
0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0			9
0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1			10
0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0			11
0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0			12
0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0			13
0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0			14
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0			15
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1			16
0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0			17
0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1			18
0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0			19
0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1			20
0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0			21
0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0			22
0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1			23
0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0			24
0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0			25
0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0			26

74 - 78

____04

																			Card Column
																*			1
0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1				2
0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0				3
0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0				4
0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0				5
0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0				6
0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1				7
0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0				8
0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0				9
0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0				10
0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0				11
0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0				12
0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1				13
0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0				14
0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0				15
0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0				16
0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0				17
0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0				18
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0				19
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1				20
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0				21
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1				22
0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0				23
0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1				24
0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0				25
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0				26

74 - 78

____0 5

																			Card Column
																*			1
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1				2
0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0				3
0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0				4
0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0				5
0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1				6
0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0				7
0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0				8
0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0				9
0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0				10
0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1				11
0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0				12
0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0				13
0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0				14
0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0				15
0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0				16
0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1				17
0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0				18
0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0				19
0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0				20
0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0				21
0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0				22
0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0				23
0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1				24
0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0				25
0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0				26
																			74 - 78
																			06

																		Card Column
																*		1
0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0			2
0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0			3
0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0			4
0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0			5
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0			6
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1			7
0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0			8
0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1			9
0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0			10
0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1			11
0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0			12
0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0			13
0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1			14
0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0			15
0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0			16
0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0			17
0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1			18
0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0			19
0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0			20
0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0			21
0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0			22
0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1			23
0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0			24
0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0			25
0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0			26

74 - 78

07

																	Card Column
																*	1
0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0		2
0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0		3
0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1		4
0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0		5
0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0		6
0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0		7
0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0		8
0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0		9
0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0		10
0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1		11
0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0		12
0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0		13
0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0		14
0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0		15
0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0		16
0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0		17
0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0		18
0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1		19
0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0		20
0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0		21
0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0		22
0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0		23
0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0		24
0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0		25
0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0		26
																	74 – 78
																	____08

																		Card Column
																*		1
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0			2
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1			3
0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0			4
0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1			5
0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0			6
0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1			7
0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0			8
0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0			9
0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1			10
0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0			11
0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0			12
0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0			13
0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1			14
0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0			15
0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0			16
0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0			17
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0			18
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1			19
0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0			20
0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0			21
0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0			22
0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0			23
0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0			24
0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1			25
0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0			26

74 - 78

09

																		Card Column
																*		1
0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0			2
0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0			3
0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0			4
0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0			5
0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0			6
0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1			7
0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0			8
0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0			9
0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0			10
0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0			11
0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0			12
0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0			13
0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0			14
0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1			15
0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0			16
0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0			17
0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0			18
0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0			19
0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0			20
0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0			21
0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0			22
0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0			23
0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1			24
0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0			25
0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0			26
																		74 - 78
																		10

																		Card Column
																*		1
0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0			2
0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0			3
0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0			4
0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0			5
0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0			6
0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0			7
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0			8
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1			9
0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0			10
0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1			11
0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0			12
0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1			13
0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0			14
0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0			15
0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1			16
0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0			17
0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0			18
0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0			19
0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1			20
0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0			21
0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0			22
0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0			23
0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0			24
0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1			25
0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0			26
																		74 - 78
																		11

																		Card Column
																*		1
0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0			2
0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0			3
0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0			4
0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0			5
0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1			6
0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0			7
0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0			8
0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0			9
0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0			10
0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0			11
0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0			12
0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1			13
0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0			14
0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0			15
0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0			16
0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0			17
0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0			18
0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0			19
0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0			20
0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1			21
0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0			22
0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0			23
0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0			24
0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0			25
0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0			26
																		74 - 78

12

																	Card Column
																*	1
0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0		2
0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0		3
0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0		4
0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1		5
0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0		6
0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0		7
0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0		8
0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0		9
0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0		10
0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0		11
0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0		12
0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0		13
0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0		14
0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1		15
0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0		16
0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0		17
0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0		18
0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0		19
0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0		20
0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0		21
0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0		22
0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0		23
0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0		24
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		25
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1		26

74 - 78

13

																		Card Column
																*		1
0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0			2
0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1			3
0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0			4
0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1			5
0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0			6
0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0			7
0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1			8
0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0			9
0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0			10
0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0			11
0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1			12
0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0			13
0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0			14
0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0			15
0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0			16
0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1			17
0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0			18
0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0			19
0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0			20
0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0			21
0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0			22
0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1			23
0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0			24
0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0			25
0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0			26

74 - 78

14

																			Card Column
																*			1
0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0				2
0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0				3
0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0				4
0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1				5
0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0				6
0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0				7
0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0				8
0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0				9
0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0				10
0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0				11
0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0				12
0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1				13
0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0				14
0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0				15
0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0				16
0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0				17
0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0				18
0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0				19
0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0				20
0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0				21
0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1				22
0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0				23
0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0				24
0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0				25
0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0				26
																			74 - 78

15

																		Card Column
																*		1
0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0			2
0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0			3
0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0			4
0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0			5
0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0			6
0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1			7
0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0			8
0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0			9
0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0			10
0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0			11
0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0			12
0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0			13
0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0			14
0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0			15
0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0			16
0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0			17
0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1			18
0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0			19
0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0			20
0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0			21
0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0			22
0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0			23
0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0			24
0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0			25
0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0			26

74 = 78

16

																	Card Column
																*	1
0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0		2
0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0		3
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		4
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1		5
0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0		6
0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1		7
0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0		8
0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1		9
0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0		10
0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0		11
0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1		12
0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0		13
0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0		14
0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0		15
0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1		16
0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0		17
0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0		18
0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0		19
0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0		20
0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0		21
0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0		22
0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0		23
0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0		24
0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0		25
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0		26
																	74 - 78

17

																		Card Column
																*		1
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1			2
0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0			3
0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0			4
0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0			5
0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0			6
0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0			7
0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0			8
0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1			9
0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0			10
0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0			11
0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0			12
0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0			13
0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0			14
0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0			15
0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0			16
0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1			17
0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0			18
0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0			19
0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0			20
0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0			21
0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0			22
0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0			23
0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0			24
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0			25
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1			26
																		74 - 78

____18

																		Card Column
																*		1
0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0			2
0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0			3
0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0			4
0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0			5
0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0			6
0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0			7
0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0			8
0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0			9
0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0			10
0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1			11
0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0			12
0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0			13
0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0			14
0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0			15
0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0			16
0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0			17
0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0			18
0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0			19
0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0			20
0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0			21
0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1			22
0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0			23
0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0			24
0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0			25
0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0			26
																		74 - 78

19

																		Card Column
																*		1
0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0			2
0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0			3
0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0			4
0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0			5
0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0			6
0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0			7
0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0			8
0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1			9
0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0			10
0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0			11
0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0			12
0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0			13
0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0			14
0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0			15
0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0			16
0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0			17
0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0			18
0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0			19
0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0			20
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0			21
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1			22
0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0			23
0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1			24
0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0			25
0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1			26
																		74 - 78

20

																	Card Column
																*	1
0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0		2
0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0		3
0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1		4
0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0		5
0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0		6
0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0		7
0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1		8
0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0		9
0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0		10
0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0		11
0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0		12
0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1		13
0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0		14
0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0		15
0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0		16
0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0		17
0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0		18
0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1		19
0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0		20
0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0		21
0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0		22
0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0		23
0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0		24
0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0		25
0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1		26
																	74 - 78

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																		Card Column
																*		1
0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0			2
0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0			3
0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0			4
0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0			5
0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0			6
0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0			7
0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0			8
0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1			9
0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0			10
0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0			11
0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0			12
0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0			13
0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0			14
0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0			15
0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0			16
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0			17
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1			18
0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0			19
0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0			20
0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0			21
0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0			22
0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0			23
0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0			24
0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0			25
0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0			26

74 - 78

22

																		Card Column
																*		1
0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0			2
0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1			3
0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0			4
0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0			5
0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0			6
0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0			7
0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0			8
0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0			9
0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0			10
0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0			11
0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0			12
0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0			13
0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1			14
0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0			15
0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0			16
0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0			17
0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0			18
0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0			19
0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0			20
0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0			21
0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0			22
0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0			23
0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0			24
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0			25
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1			26

74 - 78

23

																	Card Column
																*	1
0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0		2
0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0		3
0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0		4
0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0		5
0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0		6
0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0		7
0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0		8
0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0		9
0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0		10
0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0		11
0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0		12
0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		13
0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1		14
0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0		15
0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0		16
0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0		17
0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0		18
0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0		19
0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0		20
0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0		21
0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0		22
0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0		23
0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0		24
0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0		25
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0		26
																	74 - 78

24

																		Card Column
																*		1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			2
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1			3
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0			4
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			5
1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0			6
1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1			7
1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0			8
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0			9
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1			10
1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0			11
1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0			12
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0			13
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1			14
1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0			15
1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0			16
1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0			17
1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0			18
1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1			19
1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0			20
1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0			21
1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0			22
1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0			23
1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0			24
1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1			25
1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0			26
																		74 - 78

25

																			Card Column
																*			1
1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0				2
1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0				3
1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0				4
1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0				5
1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0				6
1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1				7
1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0				8
1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0				9
1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0				10
1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0				11
1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0				12
1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0				13
1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0				14
1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1				15
1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0				16
1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0				17
1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0				18
1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0				19
1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0				20
1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0				21
1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0				22
1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0				23
1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1				24
1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0				25
1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0				26
																			74 - 78
																			26

																	Card Column
																*	1
1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0		2
1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0		3
1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0		4
1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0		5
1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0		6
1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0		7
1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		8
1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1		9
1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0		10
1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0		11
1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0		12
1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0		13
1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0		14
1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0		15
1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0		16
1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0		17
1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0		18
1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0		19
1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1		20
1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0		21
1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0		22
1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0		23
1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0		24
1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0		25
1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0		26
																	74 - 78
																	27

																		Card Column
																*		1
1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0			2
1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0			3
1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0			4
1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0			5
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0			6
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1			7
1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0			8
1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0			9
1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0			10
1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0			11
1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0			12
1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0			13
1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0			14
1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0			15
1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0			16
1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0			17
1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0			18
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0			19
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1			20
1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0			21
1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0			22
1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0			23
1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0			24
1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0			25
1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0			26
																		74 - 78

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																		Card Column
																*		1
1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0			2
1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0			3
1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0			4
1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0			5
1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0			6
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0			7
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0			8
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1			9
1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0			10
1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0			11
1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0			12
1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0			13
1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0			14
1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0			15
1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0			16
1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0			17
1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0			18
1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0			19
1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0			20
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0			21
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0			22

74 - 78

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GLOSSARY

Assembly — The functional block at levels of the functional hierarchy above the elemental level.

ATBO — The average Time Between Occurrences of a specified malfunction or failure state for an assembly based on an assumption that the time distribution of their occurrences is exponential.

ATTR — The Average Time To Restore the assembly function to normal following occurrence of a specified malfunction or failure state.

ATTR Weighting Factor — A factor ranging from 0 to 1 used to determine the time to restore an assembly's function following the occurrence of a combination of two or three subassembly or element malfunction and failure states.

Availability — The probability that a specified assembly is functional at the start of each of the specified number of uses during the specified mission time interval.

Average Delay — The delay that the user can expect when a malfunction or failure occurs. (Also called Average Nonoperational Delay.)

Dependability — The probability of completing a specified number of functional cycles during a specified interval of time of an assembly (or element) without experiencing a malfunction or failure induced delay.

Element — The basic functional building block in the system functional hierarchy. The MTBF and MTTR data are input at this level.

Functional Cycle — The performing of an assembly's function from start to finish.

"ility" — dependability, availability and reliability

MTBF — Mean Time Between Failures of malfunctions for an element.

MTTR — Mean Time to Restore an element's function by repair, replacement or other means following occurrence of a malfunction or failure. MTTR includes the time needed to detect malfunction or failure occurrence.

Reliability	The probability that a specified assembly successfully performs its function during each of the specified number of functional cycles given that it is capable of performing its function at the start of each cycle.
Subassembly	A functional assembly becomes a subassembly when it is used at a higher level of the functional hierarchy.
TASA	Tabular System Analysis: An orderly procedure for developing the functional hierarchy of a system, defining the malfunction and failure states and recording the consequences of malfunction and failure occurrences, singly and in combination.
Unavailability	The probability that a specified assembly will not be capable of performing its function when needed because of the occurrence of a specified malfunction or failure state.
Unreliability	The probability of occurrence of a specified malfunction or failure state during one (or more) of the specified number of functional cycles of specified duration.
Use Time	The interval of time required to complete a specified number of functional cycles not counting any time between the completion of one cycle and the start of the next.

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